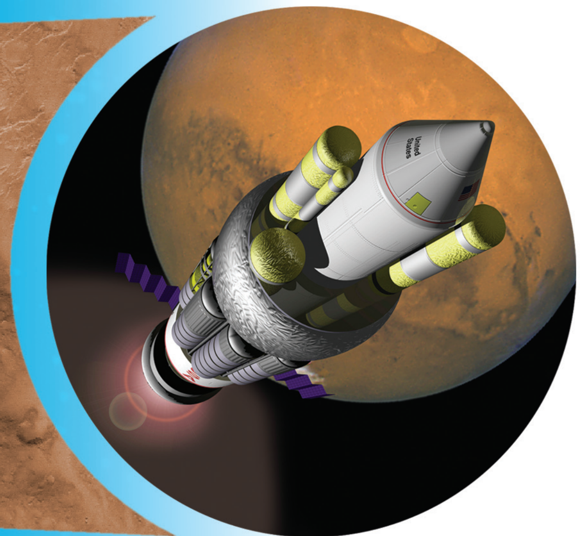
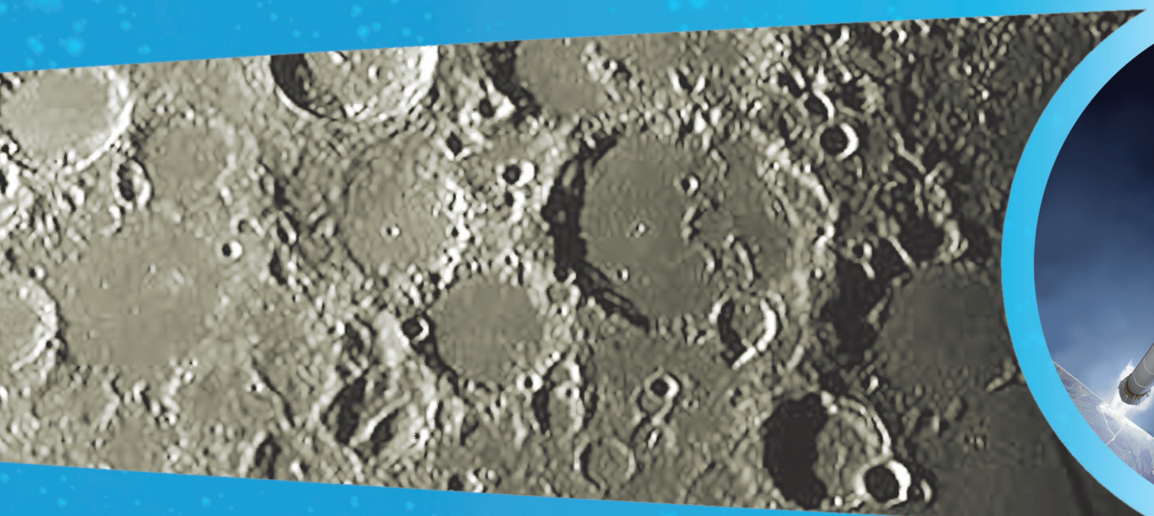
National Aeronautics and Space Administration

NASA RANGE SAFETY ANNUAL REPORT 2005





This 2005 Range Safety Annual Report
is produced by virtue of
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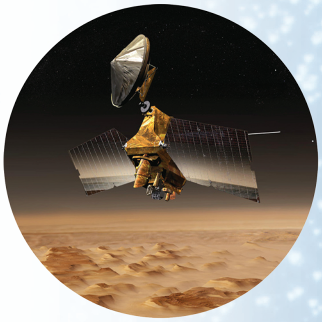
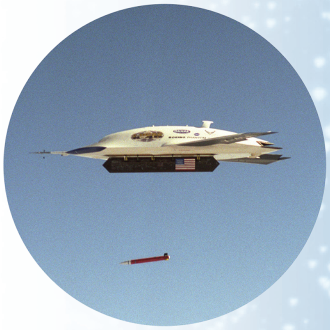




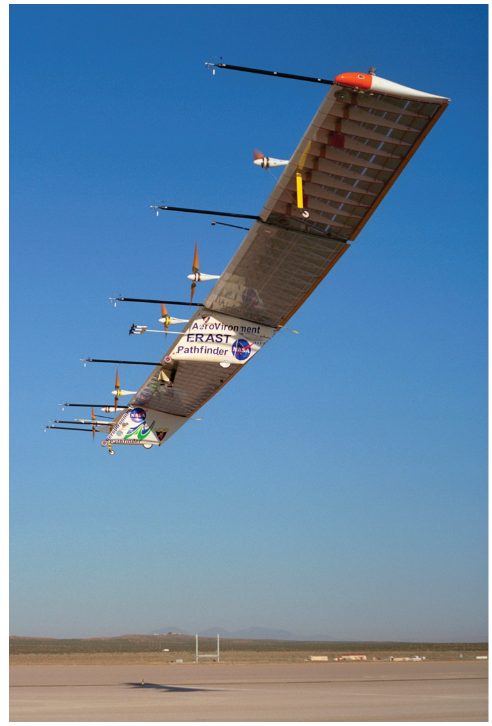
INTRODUCTION

Welcome to the 2005 edition of the NASA Range Safety Annual Report. This report is funded by NASA Headquarters and is intended to provide a NASA Range Safety overview for current and potential range users.

Contributors to this report are too numerous to mention, but we wish to thank the individuals from the NASA Centers, the Federal Aviation Administration, the Department of Defense, and civilian organizations for their contributions. Every effort was made to incorporate the most current information available. It is recommended that the report be used only for guidance and its validity and accuracy verified for any updated activities that may have occurred since its writing.

The contents provide summaries of the NASA Range Safety Program activities in 2005 and information on special topics of interest to the range safety community. The sections include highlights of the 2005 program; range safety return-to-flight contributions; new, promising range safety technologies; special interest items like the Russian launch failures and the emerging China launch program; status reports from the NASA ranges; and much, much more. The photos on this page provide a snapshot of the articles inside and a quick glimpse into the NASA range safety program. Enjoy!

Maria A. Collura, NASA
Agency Range Safety Manager



AGENCY RANGE SAFETY PROGRAM

PROGRAM OVERVIEW

NASA's range safety program is defined in NPR 8715.5, NASA Range Safety Program, dated 8 July 2005. The goal of the program is to protect the safety of the public, the workforce, and property during range operations such as launching, flying, landing and testing launch vehicles. NPR 8715.5 applies to all NASA centers and test facilities and all space vehicle programs including expendable launch vehicles, reusable launch vehicles, uninhabited aerial vehicles, experimental aerial vehicles, and the Space Shuttle and well as NASA-funded commercial ventures that involve range operations.

The purpose of the range safety program is to mitigate and control hazards, such as uncontrolled vehicles, debris, explosives, and toxics, associated with range operations. The primary approach is containment; in other words, preventing hazards from reaching people or property in the event of a mishap. When the hazards cannot be fully contained, a risk management process must be used to assess the risk in accordance with NPR 8715.5.

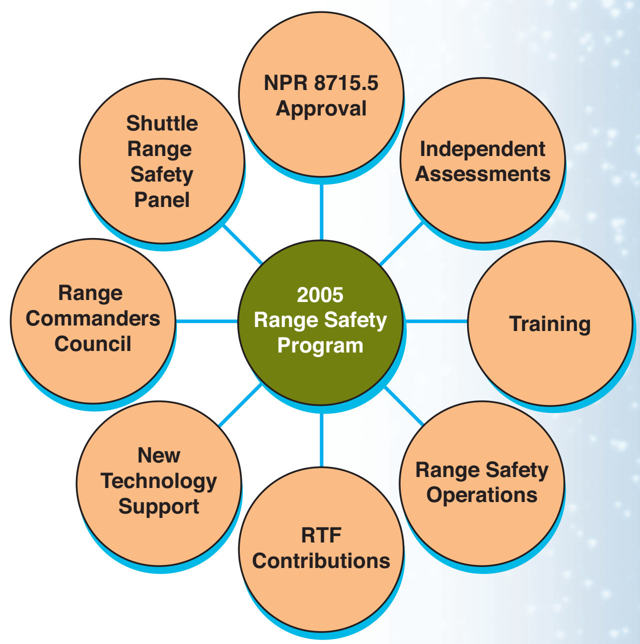
The range safety program is implemented by:

- Providing range safety training
- Performing range safety analyses early and throughout the program life cycle
- Using range safety systems, if necessary, to protect the public
- Providing or working with range personnel to provide controls, such as launch commit criteria, airspace and marine management, collision avoidance, and contingency action planning

The NASA Range Safety office was actively involved in all these processes in 2005. Some of the year's highlights include near completion of another range safety training course (third in a series), promulgation of the new NASA Range Safety requirements document, and completion of three independent assessments.

The KSC/SA staff was actively involved in refining range safety related launch processes throughout the year. Mr. Bert Garrido was instrumental in assisting the NASA Range Safety Manager and the KSC Range Safety Manager in negotiating agreements with the Space Shuttle Program, Launch Services Program, and the Air Force (45th and 30th SW), to secure a safety console position in both Air Force Operations Centers for NASA launch operations. For both programs, a Memorandum of Understanding defining roles and communication links between NASA Range Safety, the SMA Director and the Ranges was coordinated and signed to document the process.

In addition, the Range Safety Program made significant contributions to the STS-114 Return-to-Flight and participated in the development of new emerging technologies that will enhance the safety of NASA range operations. These accomplishments are discussed in the following pages before moving on to special interest items, status reports and the 2005 launch summary.



HIGHLIGHTS OF 2005

RANGE SAFETY TRAINING 2005

The Range Safety training program maintained a rapid pace during 2005. The first Range Flight Safety Analysis course took place at Kennedy Space Center (KSC), and the Range Safety Orientation course was offered three times with 66 students in attendance.

Course development also remained in high gear as the Range Flight Safety Systems course will be offered for the first time in 2006. The Range Flight Safety Operations course began to take shape as well, with full development anticipated in 2006. All of the courses continue to have a long waiting list, and centers and programs continue to request dedicated classes. The 2006 schedule of classes is shown in the graphic below.

For information concerning enrollment in the courses, visit *http://www6.jsc.nasa.gov/safety/Training*.

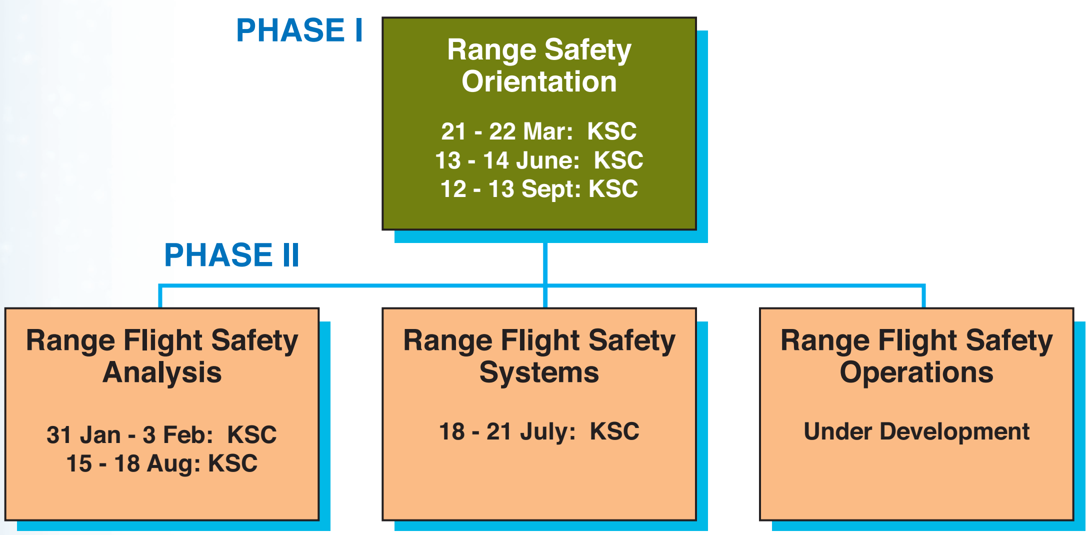
Range Safety Orientation

Range Safety Orientation remains a very popular course and a much sought after source of training for senior, program, and project managers who need to have an understanding of top-level range safety requirements. This course is designed to provide an overview of the Range Safety mission, associated policies, and requirements, as well as NASA roles and responsibilities. Students visit range safety facilities at Cape Canaveral Air Force Station and KSC. The course is normally given only at KSC.

Range Safety Training 2005

Course	Customer	Location	Dates	Students
Analysis	NTSC	KSC	15-18 Feb	12
Orientation	NTSC	KSC	22-23 Mar	14
Orientation	NTSC	KSC	14-15 June	28
Orientation	NTSC	KSC	13-14 Sept	24

Range Safety Training 2006 Schedule



Range Flight Safety Analysis

The restructured Range Flight Safety Analysis course, the first of three Phase II advanced courses, was offered for the first time in February of 2005. The course is managed by the NASA Safety Training Center (NSTC) and taught by KSC Range Safety personnel.

One of the primary roles of the Range Safety staff is to perform flight analyses to identify and mitigate public risk associated with range operations. This course provides a detailed understanding of the process of range safety analysis. It includes the following topics:

- NASA, Federal Aviation Administration, and Department of Defense requirements for flight safety analysis
- Range operations hazards, risk criteria, and risk management processes
- In-depth coverage of the containment and risk management analyses performed for Expendable Launch Vehicles (ELVs) at the Eastern Range.

Although the course is based on ELVs at the Eastern Range, the overall analysis process and concepts are applicable to other vehicles and other ranges as well. While the course concentrates on debris hazards and analyses, it includes an overview of toxic, blast, and radiation analyses. A class exercise covers the entire analysis process. The prerequisite for attending this course is NSTC 074-Range Safety Orientation or equivalent experience (an engineering degree and a background in range safety). The target audience for this course is listed below.

- NASA, Federal Aviation Administration, and Department of Defense Range Safety Analysts
- Range Safety personnel in other disciplines
- Program and project managers and engineers who design potentially hazardous systems to operate on a range
- Personnel who conduct hazardous operations on a range

Range Flight Safety Systems (FSS)

Development of the second of three Phase II courses, the Range Flight Safety Systems course, began in 2004. The course will be offered once at KSC in 2006. This four-day course focuses on flight termination system (FTS) design and operation. The course contains the seven modules briefly described below.

- FSS Overview. Introduction, lessons learned a brief history, FSS familiarization, and FSS component familiarization.
- Documents/Roles and Responsibilities. FSS requirements documentation and responsibilities and authorities.
- Design. Design philosophy, top level design requirements, tailoring, and class exercises.
- Analysis. Reliability, single point failure, and class exercises.
- Testing. Testing philosophy, testing timelines, and class exercises.
- Non-Expendable Launch Vehicles (ELVs). Uninhabited Aerial Vehicles (UAVs), Tactical Missiles, Airborne targets, and Balloons. Discussion will include basic differences of FTSs and examples.
- Other Considerations. Enhanced Flight Termination System to include shortfalls of standard, current FTSs; basic concept, components, and operation of the enhanced flight termination system. Autonomous Flight Safety System to include basic concept, components, and operation of the autonomous flight safety system. Government Furnished Equipment FTS description and potential benefits.

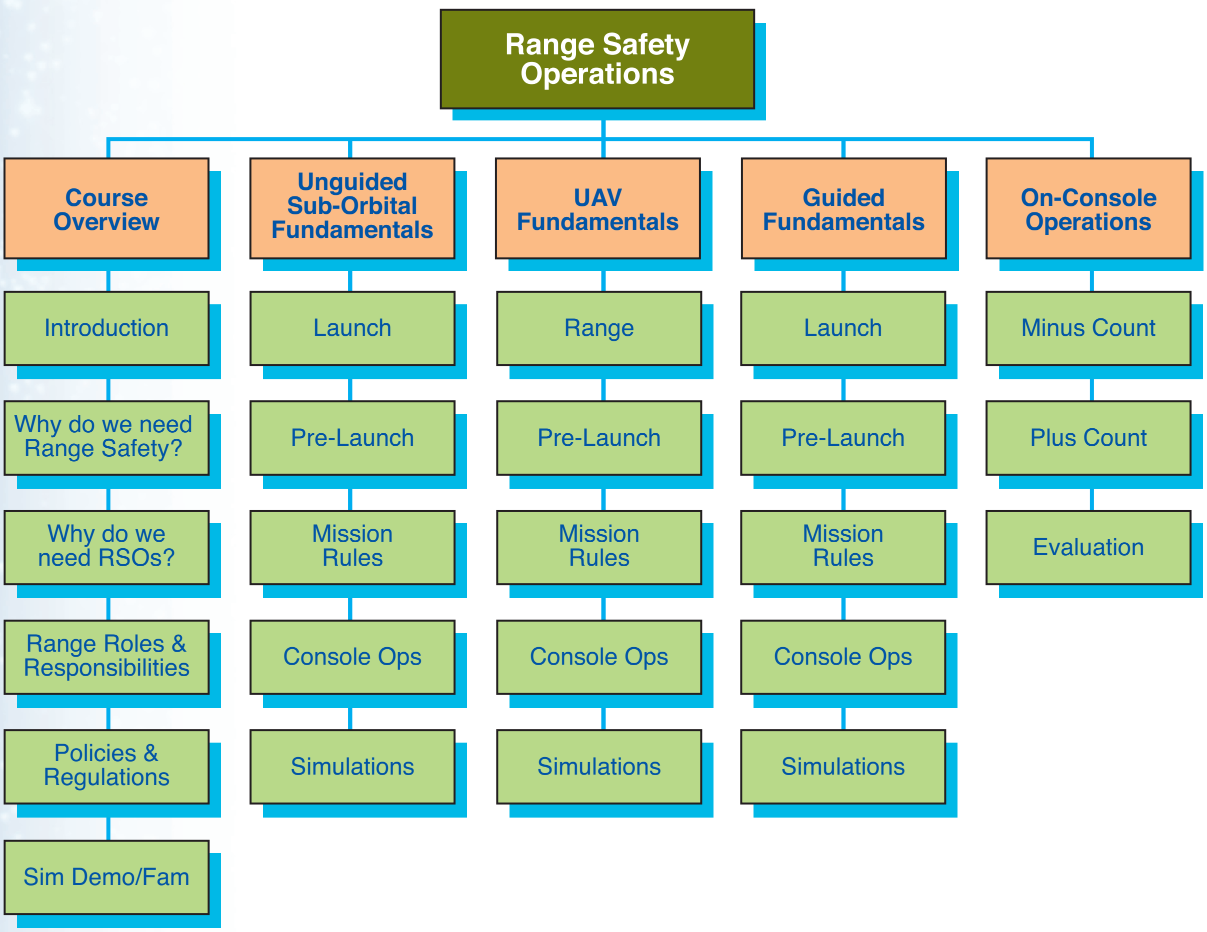
Range Flight Safety Operations

The Range Flight Safety Operations course, the last of three Phase II advanced courses, will be developed in 2006 and offered for the first time in 2007. The course will be managed by the NASA Safety Training Center and taught by several range safety operations professionals from NASA and other federal agencies involved in range safety. Unlike previous courses, this course will be taught at Wallops Flight Facility to take advantage of facility's range safety and control room facilities as well as the mobile range safety system assets.

To ensure mission success and the safety of operations for the range, a formal process has evolved among the different ranges to provide range safety operations. This course will address the roles and responsibilities of the Range Safety Officer for range safety operations as well as real time support, including pre-launch, launch, flight, entry, landing, and any required mitigation.

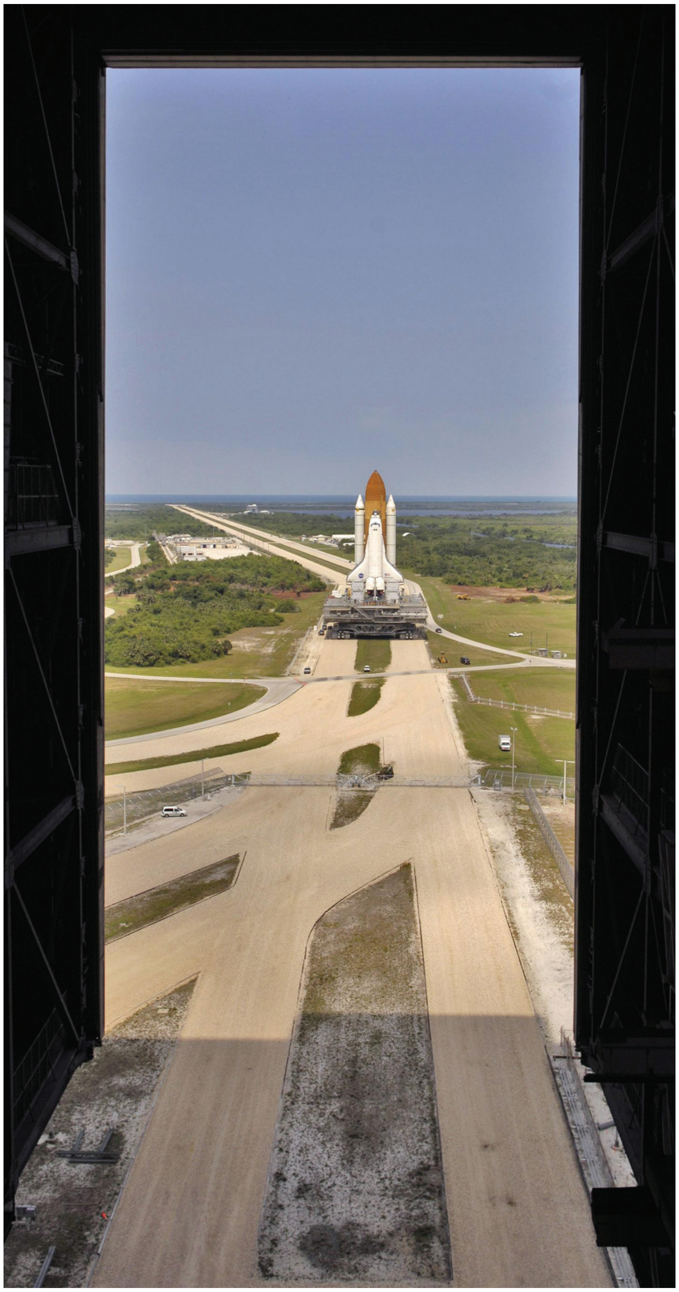
Mission rules, countdown activities, and display techniques will be presented. Additionally, tracking and telemetry, along with vehicle characteristics and sortie/range generation and checkout, will be covered in detail. Finally, post operations, lessons learned, and the use and importance of contingency plans will be discussed. Those participating in the course receive hands-on training and exercises to reinforce the instruction.

The course design document was completed in 2005. The initial design centers on the topics shown in the graphic below.



RANGE SAFETY POLICY

Development of NASA Procedural Requirement (NPR) 8715.5, *NASA Range Safety Program*, was completed during 2005. This document describes NASA's range safety policy, roles and responsibilities, requirements, and procedures for protecting the safety of the public, the workforce, and property during range operations associated with flight. The contents of this document define the agency's Range Safety Program. The NASA Administrator signed NPR 8715.5 on 8 July 2005, marking the completion of a two-year, agency-wide team effort that was greatly influenced by the loss of Columbia and the results of the ensuing accident investigation.



The Columbia Accident Investigation Board observed that NASA should "develop and implement a public risk acceptability policy" applicable to the flight of space launch and entry vehicles and the flight of unmanned aircraft. The Board did not identify this policy as something that needed to be in place for Space Shuttle Return-to-Flight. However, NASA pursued the development and implementation of this policy as part of its efforts to "raise the bar" and accomplished this effort for Return-to-Flight. The resulting policy and associated requirements incorporate NASA's approach for managing safety risk to the workforce and public during range flight operations. This policy is documented in Chapter 3 of NPR 8715.5 and represents the most significant accomplishment of the NPR development effort.

The Development Process

Development of a NASA policy requires extensive coordination with the NASA Centers and programs that will be responsible for its implementation. To aid in the development process, the NASA Headquarters Office of Safety and Mission Assurance established a NASA range safety team with members from throughout the agency. The team coordinated with the interagency range safety community and consulted with experts in applying public and workforce risk assessment to the operation of experimental and developmental vehicles. The Columbia Accident Investigation Board's lead investigator for the issue of public risk worked with the team and participated in many of the policy development activities.

As the importance of this effort was recognized, the team was asked to report directly to the NASA Headquarters Operations Council. The team presented several detailed briefings to the Operations Council and ultimately obtained Council approval of the policy. Since this effort was of interest to the public, team members participated in several press conferences and drafted a detailed discussion about the policy and its implementation, included in the publicly available Space Shuttle Return-to-Flight Implementation Plan.

The Risk Management Approach

The NASA range safety risk policy incorporates a widely accepted risk management approach that has been used successfully at United States ranges for addressing risk to the public and the workforce. The policy includes requirements for risk assessment, risk mitigation, and acceptance/disposition of risk to the public and workforce. The policy incorporates performance standards for assessing risk and contains acceptable risk criteria. Finally, the policy requires elevated management review and disposition for any proposed operations where the risk to the public or workforce might increase above the criteria.

Space Shuttle Return-to-Flight

For Space Shuttle Return-to-Flight, NASA range safety personnel worked with the Shuttle Program, the Air Force, and local authorities to implement the new policy, including the development and implementation of risk mitigation strategies for the workforce and visitors at KSC during launch. For Shuttle entry, team members at the Johnson Space Center (JSC) performed groundbreaking work to provide the Shuttle Program with assessments of public risk and to develop new flight rules that balance crew and public safety concerns when selecting among the available entry opportunities and landing sites. These flight rules were in place for the Shuttle's Return-to-Flight.

The inclusive approach taken by NASA during the development and implementation of NPR 8715.5 ensures that the Range Safety Program, which incorporates the new range safety risk policy, fully responds to the related Columbia Accident Investigation Board findings and observations and serves NASA well as it proceeds into the future of space exploration.

RANGE SAFETY INDEPENDENT ASSESSMENTS

NASA headquarters has the responsibility for conducting independent process verification reviews at NASA centers and ranges to ensure, among other things, the mitigation of operational, health, and system hazards. Reviews also include compliance with laws, executive orders, publications and standards, local operating procedures, and special interest items that pertain to the center or range.

In response to this requirement, the NASA Range Safety Manager (located at KSC) participated in three independent assessments in 2005: Dryden Flight Research Center Range Safety Systems Office, range safety related activities at Johnson Space Center, and the Wallops Flight Facility Range Safety Office.

Dryden Flight Research Center Range Safety Systems Office

The first assessment was an Institutional/Facility/Operational safety audit at Dryden Flight Research Center from 31 January to 4 February 2005. One of the ten focus areas of the review included range safety.

Objectives of the Assessment

The range safety portion of the assessment had three major objectives. The first objective was to follow up on a 2002 independent assessment of the Dryden's Range Safety Systems Office. While a number of corrective actions from the 2002 assessment were still open, most were closed by the end of the 2005 visit.

The second objective involved reviewing the Range Safety Systems Office flight analysis function. To perform flight analysis and support flight projects, the flight analysis function must make use of specialized software tools and/or mathematical calculations. These tools, such as Interim Mission Hazard Assessment Tool and Joint Advanced Range Safety System, and data spreadsheets support mission analysis and design of range safety systems. The assessment team evaluated the following:

- Pre-mission and real-time decision models, algorithms, calculations
- Certification status of operational software/ models
- Adequacy of models to address various flight situations
- Need for and status of new tools under development
- Training for analysts using the software tools

A third objective was to review the Dryden Flight Research Center/Air Force range safety interface. The NASA Dryden Flight Research Center is a civilian aeronautical test center located on Edwards Air Force Base. The commander of the Air Force Flight Test Center at Edwards is responsible for local range safety. The commander traditionally has accepted Dryden's independent range safety review process as a means for ensuring this responsibility. The assessment team evaluated the following:

- Dryden Flight Research Center interaction with Air Force range safety counterparts
- Dryden Flight Research Center/Air Force Flight Test Center interoperation support
- Air Force/Range Safety Systems Office roles in the Airworthiness and Flight Safety Review Board process

Johnson Space Center Range Safety Related Activities

The second assessment involved a weeklong Institutional/Facility/Operational safety audit of Johnson Space Center in early April 2005.

Objectives of the Assessment

The two primary objectives of the range safety review at Johnson Space Center were as follows:

- Evaluation of Johnson Space Center plans regarding implementation of the draft policy and requirements of NPR 8715.5, Range Safety Program
- Evaluation of the public risk assessment tools used to determine the public risk levels incurred as a result of vehicle entry and support entry decision-making

Wallops Flight Facility Range Safety Office

The NASA Range Safety Manager selected Wallops Flight Facility for the third assessment, conducted from 19 April to 21 April 2005.

Objectives of the Assessment

The NASA Range Safety Office had conducted an independent assessment of the facility's Range Safety Office in 2002 so one objective of the assessment was to review the status and content of the 2002 corrective actions. The review found no open corrective action items from the previous assessment. All items were in compliance with governing directives.

Other objectives focused on evaluating the three following primary areas:

- Management of the range safety ground systems
- Range safety ground system operations
- Range safety ground system hardware and software

Through these independent assessments, the NASA Range Safety Office maintains the baseline of the range safety organizations, determines the compliance or non-compliance of specific requirements, and monitors all open action items to completion. These independent assessments also continue to highlight exemplary performance and to provide an opportunity to enhance range safety programs.

HAZARD RISK

Protecting KSC's Most Valuable Resource

The NASA Safety Manual, NPR 8715.3, specifically states safety priorities for the public, astronauts and pilots, the NASA work force, and high value equipment and property. The goal of Range Safety is to ensure safety by protecting human life and property from the hazards of flight operations. To meet this goal, the risk posed to human life and property must be evaluated as either acceptable or unacceptable.

If management determines the risk is too high, then mitigations must be devised to lower the assessed risk to an acceptable level. Risk mitigation actions—based on debris, toxic, and far-field risk modeling results—must be implemented, monitored, and executed to contain the hazard.

The Self-Service Management Tool

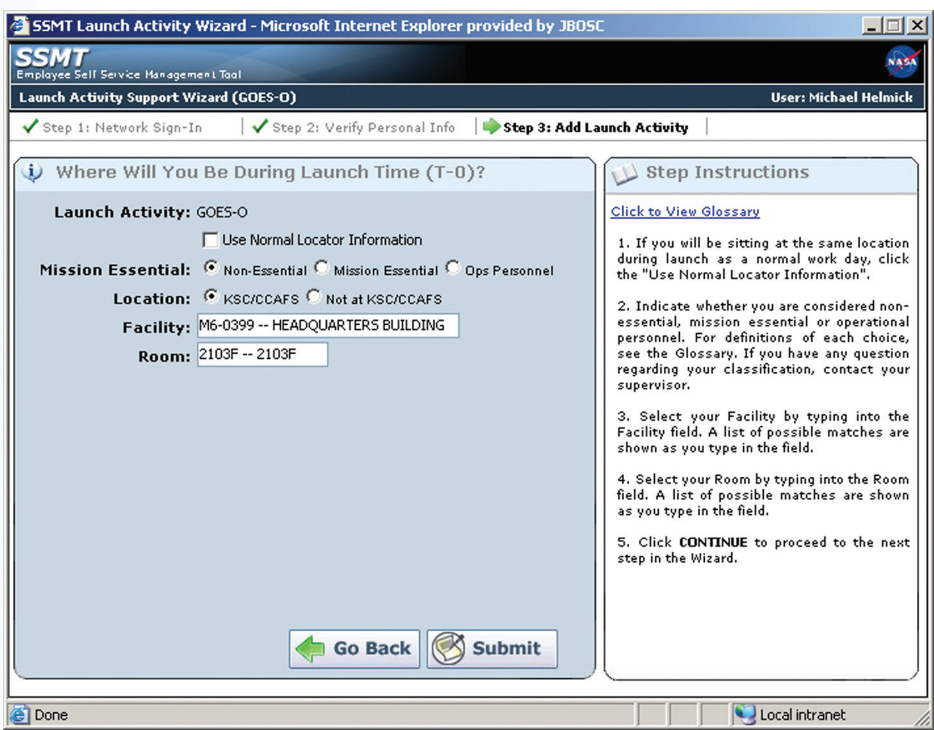
At KSC, a critical part of ensuring safety involves accurately identifying the location of personnel during normal and launch day operations. Knowing individual shift times—day, night, and weekend—is also important. The Self-Service Management Tool (SSMT) is one of the prime information sources for Range Safety analysts to use to assess risk to KSC personnel and property. The program has been updated and streamlined to accept an individual's location, the time of day, and mission status.

To access the SSMT database system, visit *http://ssmt.ksc.nasa.gov/launchactivitywizard*. Links are also provided to the Launch Activity Support Wizard from the KSC internal page and SSMT's home page. The graphic below shows the screen used to identify launch work location and mission status.

Other Safety Considerations

Along with the type of launch vehicle, this information about personnel is used with numerous other parameters, such as winds, building structures, and failure rates, required by range safety analysts to determine risk numbers. A recent survey was completed to update structural information of the top 20 "blast risk" facilities at KSC, most of which are located in the Launch Complex 39 area.

The continued use of the Self-Service Management Tool program greatly enhances the protection of KSC's most valued resource—its people.



PLANS FOR LAUNCHING AND LANDING THE SPACE SHUTTLE

Early in 2005, NASA Range Safety initiated a comprehensive review of KSC specific risk management criteria for the launch and landing of the Space Shuttle. The result of these efforts culminated in the development of two new KSC Plans: KSC-PLN-2804, KSC Range Safety Implementation Plan for the Landing of the Space Shuttle, and KSC-PLN-2805, Range Safety Risk Management Plan for the Launch and Landing of the Space Shuttle.

Range Safety Risk Management Plan for the Launch and Landing of the Space Shuttle

The KSC Range Safety Risk Management Plan for Launch and Landing of the Space Shuttle outlines the KSC risk management process consisting of risk assessment, hazard containment, and risk mitigation strategies for launch and landing of the Space Shuttle. At the same time, the plan addresses NASA policy regarding range safety in NPR 8715.5 Range Safety Program. It is anticipated that KSC pre-launch planning will result in meeting all the NPR launch criteria for falling debris, toxics, and far-field overpressure hazards.

The KSC Range Safety Manager will update the risk management plan at least every two years to reflect current operations and risk levels. The risk management process for launching and landing the Space Shuttle includes established Air Force and NASA processes using containment and risk analysis as well as a KSC risk assessment process to address situations where residual risk violates policy criteria contained in NPR 8715.5. This risk management process involves pre-launch and landing preparation and real-time communications between the Air Force and KSC and results in a strong risk management methodology.

KSC Range Safety Implementation Plan for Landing of the Space Shuttle

The KSC Range Safety Implementation Plan for Landing of the Space Shuttle outlines hazard containment and risk mitigation strategies used to implement the KSC Range Safety Risk Management Plan for Launch and Landing of the Space Shuttle in accordance with the requirements of NPR 8715.5. The goal is to meet all the NPR individual and collective risk criteria for falling debris during nominal end-of-mission, return-to-launch-site operations. This plan will also be updated by the KSC Range Safety Manager at least every two years to reflect current operations and risk levels.

The implementation plan for landing the Space Shuttle is a combined effort, with Johnson Space Center providing detailed risk analysis and KSC providing input data and assessing the results. KSC provides Johnson with a population database for KSC visitors and workforce that includes the expected numbers of people as well as their planned locations during entry. In turn, the Johnson Space Center, Mission Operations Directorate, Flight Design and Dynamics Division enters this data in the entry risk model and provides KSC with a detailed listing of expectation of casualty results for the public and workforce on KSC property. The data also highlight locations of high individual and collective casualty expectation and help establish keep-out zones.

EMERGING TECHNOLOGY

SPACE-BASED TELEMETRY AND RANGE SAFETY (STARS) 2005

It has been another busy and productive year for the Space-Based Telemetry and Range Safety (STARS)—a multicenter NASA project to demonstrate the performance, flexibility, and cost savings of using space-based communications assets during vehicle launches and landings.

Changes to STARS

After the initial series of F-15 flights at Dryden Flight Research Center in 2003, the range safety low-power transceiver, command and data handler, and the Global Positioning System (GPS) receiver components were combined into a single unit called the range safety unit. The forward (command) flight termination signal link rate was increased from 400 bits per second to 840 bits per second and Triple-DES encryption was added. Reed-Solomon encoding was implemented on both the forward and return (telemetry) links, and the range user system was upgraded to a higher data rate Ku-band system with a steerable, phased-array antenna.

GlobalFlyer Mission

STARS provided the communications system for real-time cockpit video during the historic flight of the GlobalFlyer experimental aircraft that made the first solo non-stop, non-refueled flight around the earth in March 2005. The range safety unit was modified and installed in the aircraft in less than four weeks and provided low-rate video (57 or 114 kilobits per second, corresponding to about 1 to 2 frames per second). The range safety unit inside the GlobalFlyer cockpit is shown below.

A video data compressor converted (PAL) video to compressed digital video, which was then relayed via the tracking and data relay satellite system to the White Sands Complex—the location of the satellite system ground terminal—and sent over land lines to the GlobalFlyer control room at Kansas State University at Salina for display and distribution over the Internet. This video was used in conjunction with an Iridium voice link during pilot interviews throughout the mission. The range safety unit performed well during the three-day flight.

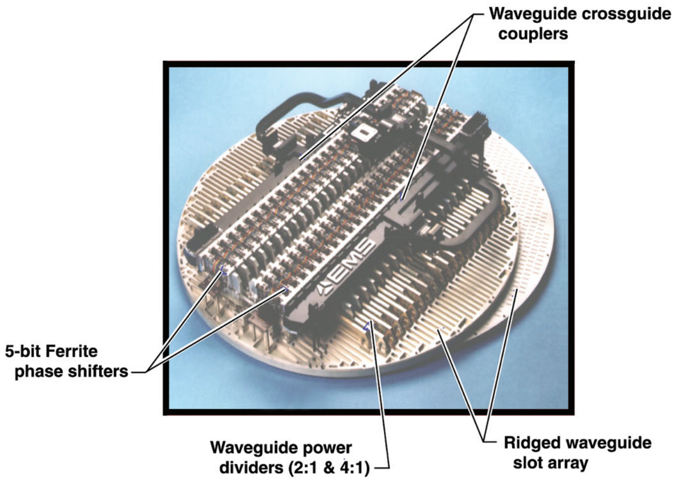
GlobalFlyer presented an excellent opportunity to compare predicted and actual link margins for many hours during mostly straight and level flight using a simple one-antenna configuration on a nonconductive airframe. There were no environmental problems and the measured link margins generally exceeded the predicted by about 3 decibels. No attitude information was available, so the predicted models assumed a straight and level profile. This was a reasonable assumption since GlobalFlyer was not designed for dynamic flight and flew nearly straight and level with only very gradual and careful flight maneuvers. This flight experience and data will be useful for future STARS test flights.

Orion Sounding Rocket Mission

The STARS Range Safety system flew on a Terrier MK70 Improved-Orion sounding rocket at Wallops Flight Facility on December 20, 2005. This flight tested the range safety system at Mach 5 speeds and altitudes up to 200 kilometers on a rocket spinning at 4 to 5 hertz with wrap-around S-band antennas. Two tracking and data relay satellites were used simultaneously for the forward flight termination commands and the return telemetry streams. The hardware was successfully recovered. Preliminary analysis indicates that the system performed well with minimal dropouts and large link margins.

F-15 Flights

There has also been work to prepare for another set of F-15 flights at Dryden Flight Research Center in mid 2006 to test a Ku-band range user system with the phased-array antenna from EMS Technologies shown below.

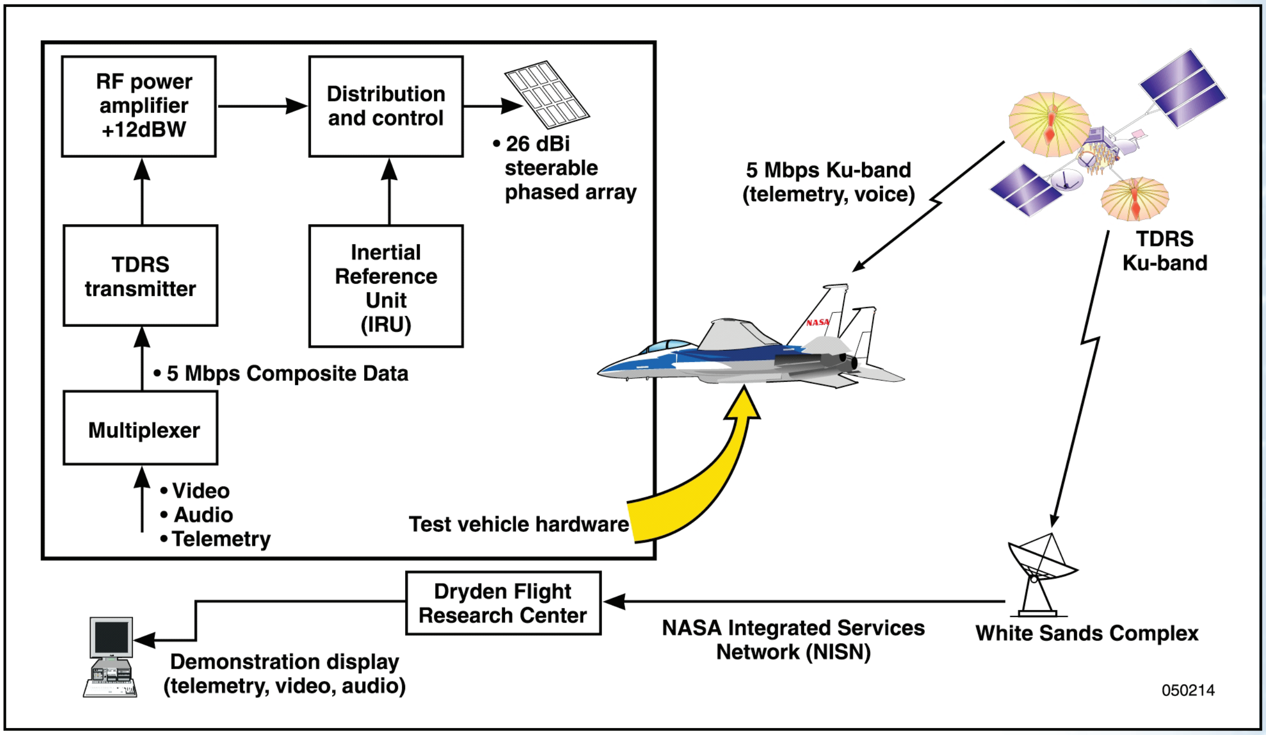


The goal is to achieve a data rate of 5 megabits per second. The antenna is electronically steerable in elevation and mechanically steerable in azimuth and will be mounted on top of the F-15 behind the cockpit. The test configuration is shown below.

AUTONOMOUS FLIGHT SAFETY SYSTEM – PHASE III

The Autonomous Flight Safety System (AFSS) is a joint KSC and Wallops Flight Facility project currently in its third phase of development. The AFSS is an independent and autonomous flight termination subsystem intended for expendable launch vehicles. It uses tracking and attitude data from onboard Global Positioning System (GPS) and Inertial Measurement Unit (IMU) sensors and configurable rule-based algorithms to make flight termination decisions.

The objectives of the AFSS are to increase capabilities by allowing launches from locations that do not have existing range safety infrastructure, reduce costs by eliminating some downrange tracking and communications assets, and increase safety by reducing the reaction time for flight termination decisions.



2005 Accomplishments

Phase III testing and development included the following accomplishments:

- Improved efficiency and accuracy of mission rule algorithms
- Expanded set of mission rule algorithms
- A data display monitor to display telemetry in real-time and archived data for post-flight analysis
- Baseline design for multiple input sensors, multiple flight processors, and redundant command switch logic and interlock circuit
- Extensive simulation testing
- Ground vehicle test
- Aircraft test
- AFSS chassis environmentally tested and ready to fly on a sounding rocket

Flight Processor Mission Rules

A full AFSS system consists of redundant chassis, each containing two independent flight processors, one internal GPS sensor and/or connections to external GPS/IMU sensors, and a command switch logic and interlock circuit responsible for initiating the firing sequence.

Each processor is loaded with the mission rules. During the flight, the data from each GPS/IMU sensor is available to each flight processor and the rocket's current trajectory is continually checked against the mission flight rules. Each command switch logic and interlock circuit simultaneously monitors the state (Monitor/Arm/Fire) of all flight processors and initiates a destruct based on the majority vote.

The mission rule algorithms are configurable for each vehicle/mission by the responsible Range Safety authorities and can be categorized as follows:

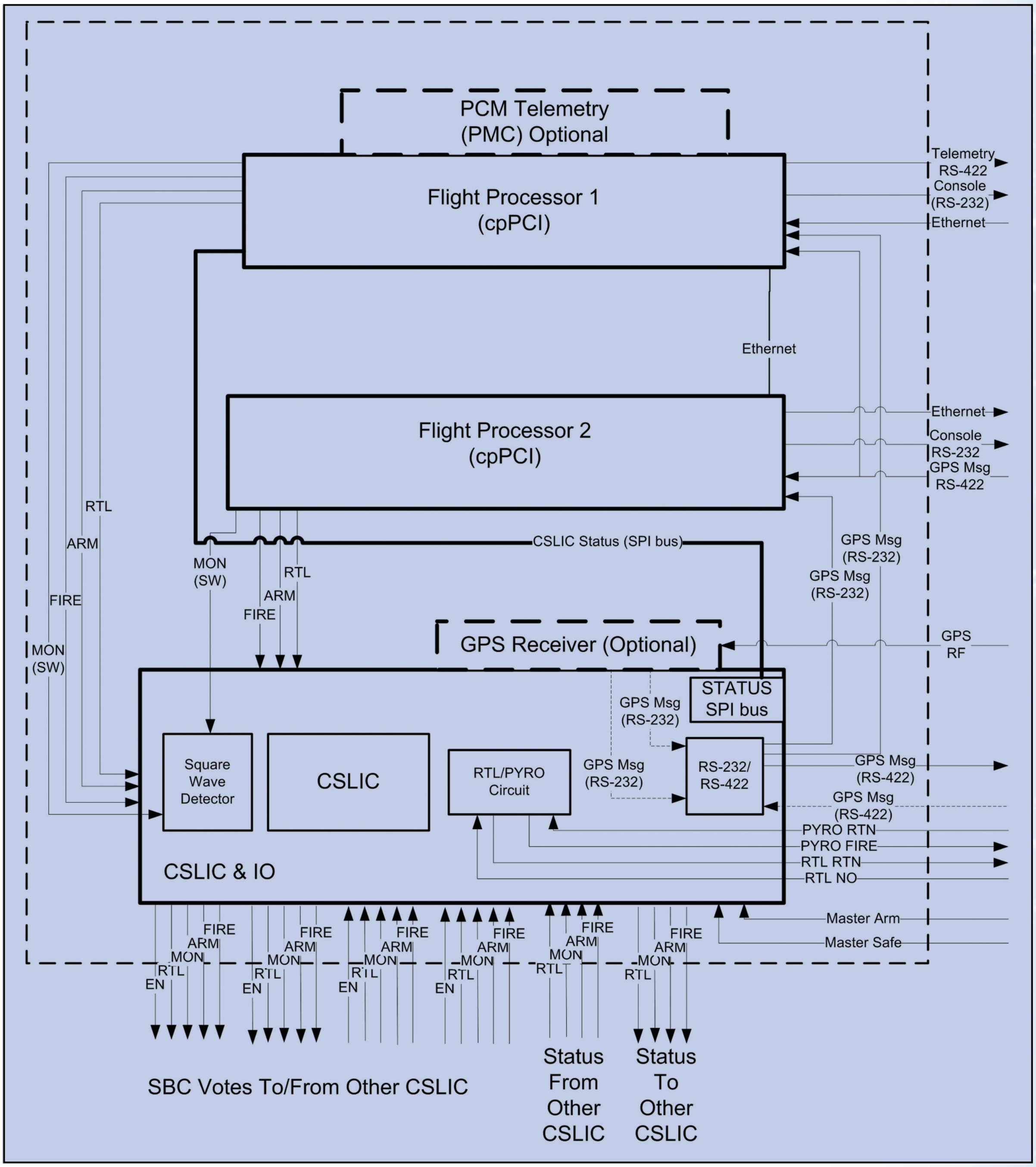
- Rocket stage ignition and burnout detection
- Parameter Threshold Violation – a trajectory value exceeds an allowed limit
- Physical Boundary Violation – present position or instantaneous impact point is out of a corridor or in an exclusion zone
- Two-Point Gate Rule – determines if a current position or instantaneous impact point has crossed a gate formed by two points
- Moving Gate Rule – determines if the current position or instantaneous impact point is in front of or behind a moving two-point gate
- Green-Time Rule – determines how long the rocket can safely fly without receiving valid updated tracking data

Extensive testing was done using a GPS constellation simulator and launch trajectories for several different multi-stage vehicles and launch sites.

First Test on a Moving Vehicle Using Live Data

The first test on a moving vehicle using live data was also conducted. A minivan with a GPS sensor on the roof was driven around the KSC Industrial Area in a corridor that was surveyed prior to testing. The following algorithms were tested successfully:

- Parameter Threshold Violation – a speed limit was exceeded. This was a contrived but useful test for a generic parameter threshold violation.
- Physical Boundary Violation – the present position went out of the allowed region through a boundary that was not an exit gate.
- Two-Point Gate Rule – the west end of the test region was defined to be a two-point gate that could be crossed without causing a physical boundary violation.



AFFS Unit Functional Diagram

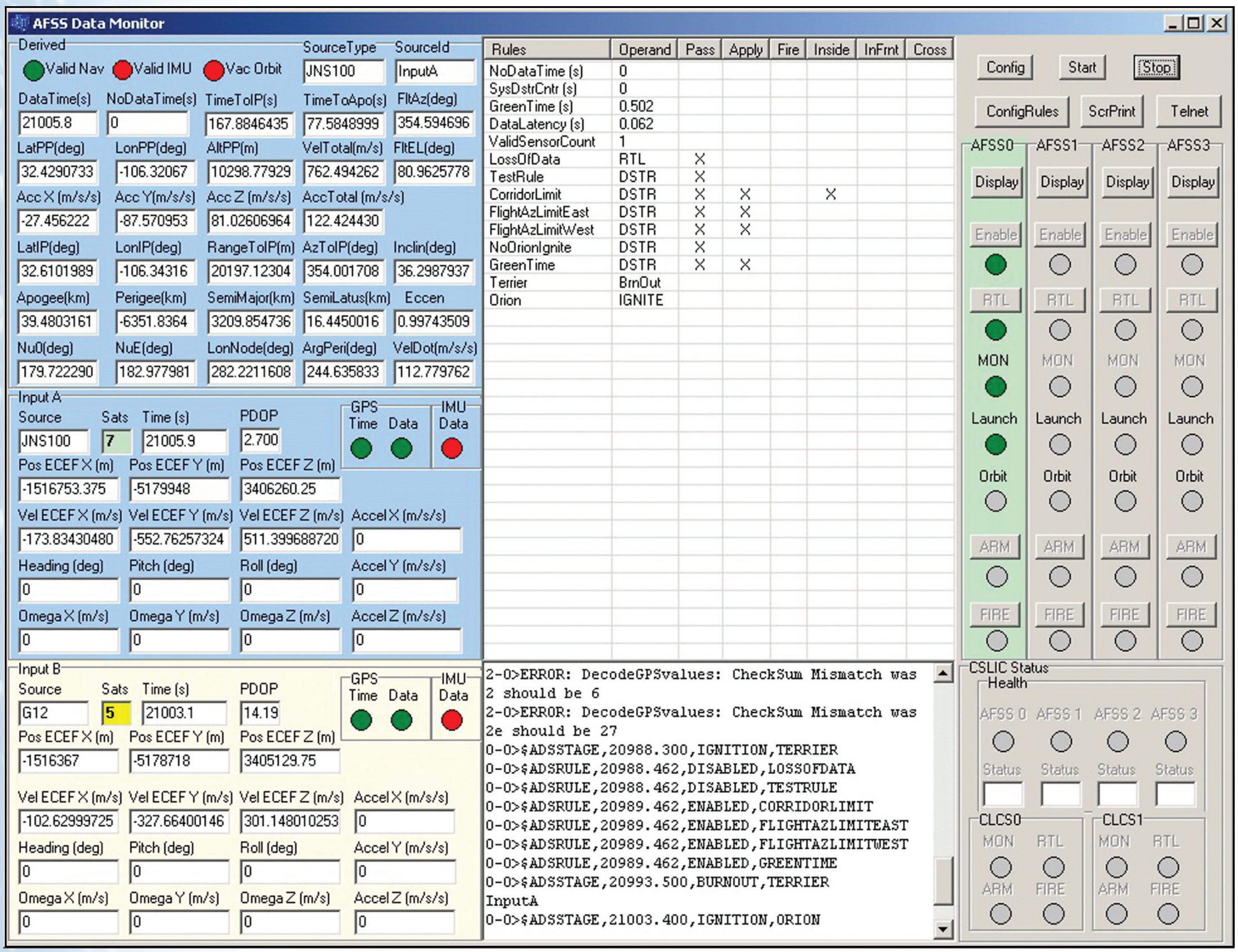
The test and the results are described in detail in Autonomous Flight Safety System Road Test, KSC-YA-7738. This report has been approved for public release. To obtain a copy of the report, contact Dr. Jim Simpson at *james.c.simpson@nasa.gov.*

Aircraft Flight Test

An aircraft flight took place in September 2005 on a Cherokee 235 over the St. Johns River west of KSC to test instantaneous impact point limits and three-dimensional static and moving gates. All the tests were successful and the algorithms and hardware performed as expected. The test and the results are described in detail in Autonomous Flight Safety System September 27, 2005, Aircraft Test, KSC-KT-7971. To obtain a copy of the report, contact Dr. Jim Simpson.

Sounding Rocket Flight Test

A Terrier Improved-Orion sounding rocket flight at White Sands Missile Range is currently scheduled for early 2006; however, the AFSS will not be operational and will not be connected to any pyrotechnics. Two prototype AFSS chassis based on the PC104+ platform have been built. One will be the primary flight chassis and the other will act as a backup. Each chassis has two independent flight processors, one internal GPS sensor, and connections to one external GPS sensor. One processor will be loaded with rules that should not destruct during a nominal flight, while the other processor will be loaded with rules that should destruct during a nominal flight. Both AFSS units have successfully passed the required environmental testing.



The performance of the two different GPS sensors to be used for the sounding rocket flight has already been evaluated. Using three different simulations, the navigation solutions of each receiver agreed with both the input trajectories and internal simulator truth files to within a couple of meters in position and less than a meter per second in velocity. The results gave the AFSS team confidence that both sensors will perform nominally during the sounding rocket flight. Integration of the AFSS unit with the rocket's telemetry system is underway.

A PC-based data display monitor was developed to display the GPS solutions of both GPS receivers, as well as which GPS solution is currently being used by the AFSS algorithms. The data display monitor also shows the flight rules and their current status. Other indicators display the current state of the flight processors and informational and warning text messages. An example display is shown on page 16.

The AFSS team continues to have close contact with the range community for their input in shaping the final requirements, design, and testing of the AFSS concept. The goal is to have a flight-qualifiable unit by mid 2006 built around a rugged, compact PCI processor. More test flights are planned as vehicles become available.

ENHANCED FLIGHT TERMINATION SYSTEM PROGRAM

The objective of the Enhanced Flight Termination System program is to develop the next generation flight termination system for the Department of Defense and NASA ranges. The program addresses robust command links for flight termination, including message formats, modulation methods, and encryption.

Previous Status

The Range Safety Group of the Range Commanders Council initiated a study task and ultimately selected continuous phase frequency shift keying as the modulation scheme, a 64-bit triple data encryption standard for security, and the layout of the 64-bit message for the new system. The Air Force Flight Test Center then let a contract to build prototype enhanced flight termination receiver decoders and an encoder for the ground transmitter. The receiver decoder and encoder units successfully demonstrated that the enhanced flight termination system would function in flight and in an operational setting. In August 2004, two contracts to develop the enhanced flight termination receiver decoder engineering development units were awarded to L-3 Cincinnati Electronics (CE) and Herley Industries.

Current Accomplishments

Currently, the Central Test and Evaluation Investment Program is funding the development of the flight termination receiver decoders, encoders, monitors, and encryption units for different range applications, such as uninhabited aerial vehicles, space launch vehicles, and missiles. Milestones accomplished this year are described below.

- During the first quarter of 2005, a request for proposal for the development of the encryption unit, encoder, and monitor was released and a contract awarded to L-3 CE in August. A system design review and a preliminary design review have already been held to resolve issues. Early delivery of the contracted hardware is expected.
- In June 2005, L-3 CE successfully delivered the flight termination receiver decoder engineering development unit shown below at the critical design review and was awarded a delivery order for qualification units with an expected Summer 2006 delivery date.
- In November 2005, the Herley Industries critical design review was conducted.

Future Plans

The Enhanced Flight Termination System program plans to test the operational hardware on an advanced, mid-range, air-to-air missile in the summer of 2006 using the qualified flight termination receiver and the ground equipment currently under development.

The final phase of the program provides the mechanism to field ground systems for production and deployment on all Department of Defense and NASA ranges. This part of the program is expected to begin in the 2007 timeframe.

JOINT ADVANCED RANGE SAFETY SYSTEM

The purpose of the Joint Advanced Range Safety System (JARRS) program is to develop a state-of-the-art mission planning, risk analysis, and risk management tool for range safety. The program is a collaborative effort between Dryden Flight Research Center and the Air Force Flight Test Center at Edwards Air Force Base.

Range Safety organizations from all major Range and Test Facility Bases are being asked to support the development, testing, and operation of uninhabited aerial vehicles (UAVs) and reusable launch vehicles (RLVs). It is the vision of JARRS to provide range safety support for these missions. The JARRS consists of two primary elements: a mission analysis software tool and the real-time operations tool.

Mission Analysis Software Tool

Using a computerized methodology, the JARSS mission analysis software tool quantifies the range safety risk for a given flight path and its associated vehicle parameters. Computerization streamlines range safety analysis by providing a consistent, high fidelity solution in less time than required by present methods of analysis.

The mission analysis software tool is nearing completion as work on the closeout task continues. Dryden's JARSS development lab is running software Version 2.2. The mission analysis software tool is slated to receive 2006 funding to begin independent software verification and validation from NASA's Independent Verification and Validation Facility in West Virginia. The goal is to make the mission analysis software tool available for government use by the end of 2006.

Real-Time Operations Tool

The real-time operations tool provides the Range Safety Officer with near real-time assessment of the range safety risks during flight. This capability has many possible applications to the UAV or RLV operator, including assessment of UAV overflight of populated areas, allowing extended flight of an anomalous vehicle, recovery of an off-nominal vehicle at an alternate landing site, or selection of an alternate flight or entry path. Work on the JARSS real-time operations tool has not begun.

BALLISTIC MISSILE RANGE SAFETY TECHNOLOGY PROGRAM

The Ballistic Missile Range Safety Technology (BMRST) program is a range safety command and tracking system that is managed by the 114th Range Operations Squadron of the Florida Air National Guard. BMRST is currently undergoing Eastern Range acceptance. When accepted, the system will be capable of providing launch site or down range support, either independently or in conjunction with other Eastern Range systems.

The goal of the program is to develop and certify a mobile system that will supplement and enhance launch data and public safety systems at space launch ranges.

The BMRST systems consist of a mobile operations center, two OMNI antennas, and two trailer-mounted 5.4 meter directional antennas. The directional antennas are dual use, capable of receiving and transmitting concurrently, as required. The mobile operations center houses an operations crew of four, along with all data processing equipment. The center also houses two range safety positions and is capable of transmitting command destruct signals as required for safety during flight. The entire BMRST system can be transported over the road or in a single C-17 or C-5 aircraft.

The system also supports the capability to integrate a Global Positioning System (GPS) reference base station and associated antenna. It receives flight vehicle based GPS and inertial guidance derived position and velocity data, processes the data, computes and displays the instantaneous impact point of the vehicle related to the theoretical trajectory, as well as impact limit lines. The vehicle translational and rotational states are also displayed for comparison with those of the theoretical trajectory.

Once accepted for use, BMRST systems will augment range capabilities and increase flexibility as they can be easily moved to support range requirements.

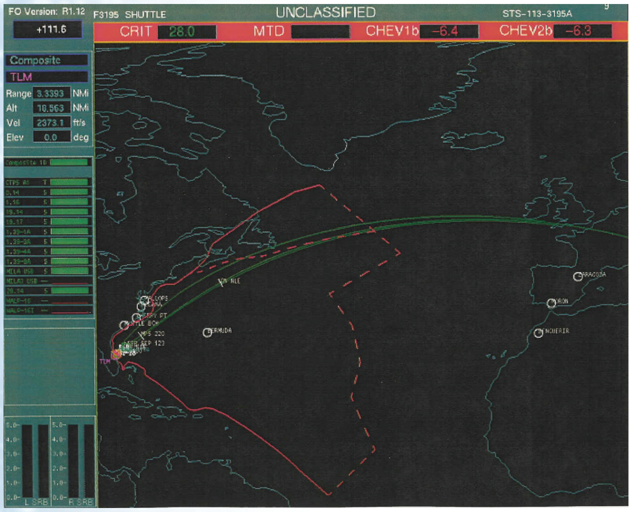
EASTERN RANGE RANGE SAFETY INSTRUMENTATION UPDATE

The United States Air Force's 45th Space Wing supports NASA activities at KSC and Cape Canaveral Air Force Station (CCAFS). The Eastern Range provides the activities and resources for flight safety (including public safety), range instrumentation, infrastructure, and scheduling required to support and assure space and ballistic launches and other operations. Eastern Range range safety instrumentation is comprised of legacy and newly acquired state-of-the-art technologies to support the launch mission of the 45th Space Wing.

Eastern Range instrumentation equipment is located on Cape Canaveral Air Force Station, Patrick Air Force Base, Malabar Annex, Jonathan Dickinson Missile Tracking Annex, and KSC, in addition to Antigua, Argentina, and Ascension stations. The Eastern Range also uses instrumentation from other Department of Defense and NASA agencies to accomplish its mission. Some of the major instrumentation systems that support Range Safety have recently been updated.

Flight Operations Version One

Flight Operations Version One (FOV1) consists of two independent systems that are located in the Range Operations Control Center on Cape Canaveral Air Force Station. The FOV1 systems provide the capability for Range Safety to monitor launch vehicle performance. The systems acquire and process instrumentation data from Cape Canaveral Air Force Station and off-range sites through redundant network paths. Using the instrumentation data, these systems generate flight path and predicted impact point displays.



Using these displays, the Mission Flight Control Officer determines the risk based on pre-defined mission rules and, if required, terminates any vehicle that violates established flight destruct criteria. The system resides in the FOV1 Controls and Display room.

FOV1 was initially accepted into the Eastern Range inventory 18 September 2003. It went through an upgrade and development effort called fix-it-first that was completed in December 2005. The fix-it-second development effort will follow and will be completed in early 2007.

Post Detect Telemetry System

The latest telemetry system acquired by the Eastern Range is the Post Detect Telemetry System (PDTS). This system was accepted into the Eastern Range inventory 27 October 2005 and enhanced many of the Eastern Range range safety critical systems. PDTS provides transport of digital post-detect telemetry data from Eastern Range telemetry sites via the Network Core System Wide Area Network Interface Units and the microwave and commercial circuits from Jonathan Dickinson Missile Tracking Annex.

PDTS sites include Tel-4 on KSC, Jonathan Dickson, Antigua, and Ascension. Timing and sequencing system components provide the synchronization signals required for the PDTS and the Network Core System equipment operation. The post-detect telemetry data is transported to the launch customer facilities and the Range Operations Control Center (ROCC) for range safety purposes.

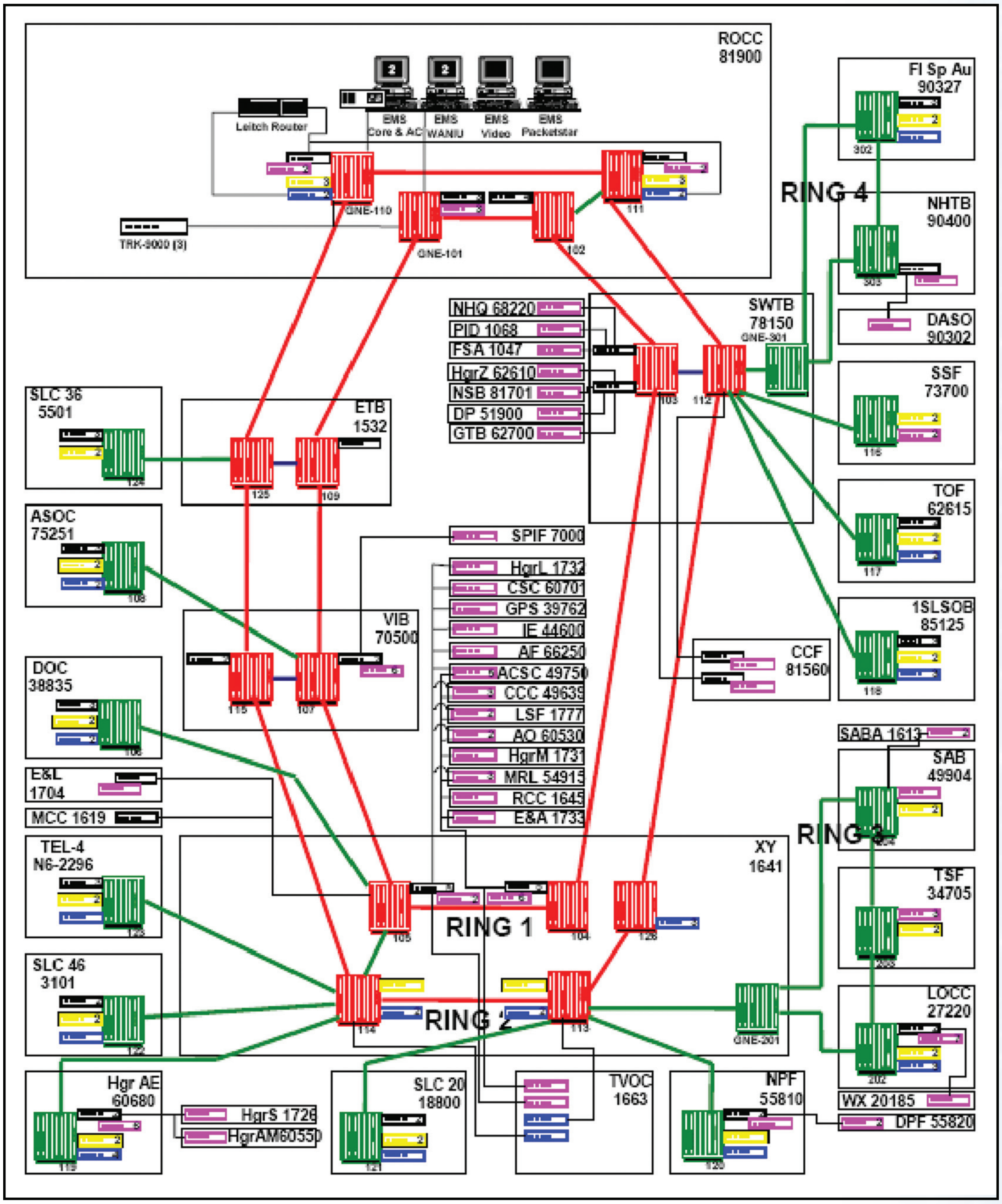
INTELSAT SATCOM System

The INTELSAT SATCOM System (side B) was modified as part of the PDTS project to support new bandwidth, polarization, and modulation format requirements. This new digital service is configured as the Eastern Range primary telemetry transmission carrier from downrange stations at Antigua and Ascension to the Range Operations Control Center.

Core Data Wide Area Network Interface Units

Core Data Wide Area Network Interface Units System is the major transport mechanism to Range Safety and telemetry data end users. The Core—shown in the diagram below--provides the communication backbone at Cape Canaveral Air Force Station. The Core consists of four rings, two OC-48 (red 2488 megabits per second) and two OC-12 (green 622 megabits per second). The communication link to NASA is through the Launch Operation Control Center. The primary nodes shown in the diagram are listed at right:

- ROCC (Range Operations Control Center)
- XY Facility
- VIB (Vertical Integration Building)
- SWTB (Southwest Terminal Building)
- ETB (East Terminal Building)



UNINHABITED AERIAL VEHICLES

Uninhabited aerial vehicles (UAVs) are aircraft that are controlled remotely, autonomously, or a combination of both and are operated in a manner consistent with a "conventional" aircraft. UAVs fall into two categories: experimental and operational. For example, experimental UAVs may be used to test a new aerodynamic shape while operational UAVs with proven flight experience are used strictly as airborne platforms with payloads and experiments on board. The operational category of vehicles also includes vehicles dropped from other aerial vehicles, subscale flight test vehicles, or lifting bodies. UAVs may travel at speeds ranging from slow subsonic (20 to 30 mph) to hypersonic (700+ mph).

UAVs may also be referred to as unmanned air vehicles, unmanned aerial vehicles, remotely piloted aircraft, remotely operated aircraft, or remotely piloted vehicles. Model aircraft—normally vehicles of less than 55 pounds gross weight flown under manual control within unaided visual contact range—are not considered UAVs.

Development of a UAV Program

In August of 2005, the KSC Spaceport Engineering and Technology directorate initiated development of a UAV program to support future programs at KSC, Cape Canaveral Air Force Station, and Patrick Air Force Base. To aid in meeting program requirements, the 45th Space Wing Safety Office and the KSC Range Safety Office are in the process of jointly developing a UAV range safety requirements document, UAV flight certification approval process, UAV concept of operations, operational agreements, project and program interface, and technical product compliance standards.

It is KCS's responsibility to take all reasonable precautions to identify, evaluate, and mitigate safety related risks to protect the general public, the NASA work force, and high value assets through ground safety, flight safety, and range safety. An in-depth research of current safety related documents, as well as coordination and interface with Wallops Flight Facility, Dryden Flight Research Center, and Patuxant River Air Test Center, is being conducted to identify range safety policies, processes, procedures, standards, and requirements for safe UAV operations.

KSC's Role in UAV Operations

The KSC role in UAV operations may be as a user, sponsor, host, or any combination of the three. Each role encompasses unique responsibilities and safety requirements for UAV operations conducted at KSC.

The UAV User at KSC

In this operation, KSC acts as the owner and operator of the vehicle and any flight is considered a NASA (or NASA contractor) developed mission that requires a range safety program and will use range assets as part of its program. In this capacity the UAV project takes on traditional roles and responsibilities with respect to mission success, ground safety, flight safety, and range safety as documented in NPR 7120.5C, NASA Program and Project Management Processes and Requirements.

The UAV Sponsor at KSC

If the project is owned and operated by an outside organization funded by NASA, it becomes a relationship between the project and KSC sponsor, wherein KSC will have range safety, flight safety, ground safety, and mission success responsibilities based on a memorandum of understanding or agreement. Similar to the user at KSC relationship, the project comes to KSC to use assets and personnel to accomplish mission objectives. Based on the memorandum of understanding or agreement, KSC Range Safety will only participate and review project activities to a level that adequately evaluates and ensures safety for its areas of responsibility.

The UAV Host at KSC

If the project is owned and will be operated on the range by an outside organization, KSC Safety does not have any flight responsibilities for range safety, flight safety, or mission success. KSC's only role will be to provide facility support and ground safety. KSC Ground Safety will participate and review project activities to a level that adequately evaluates and ensures safety for its areas of responsibility.

Based on KSC's involvement (user, sponsor, host) and the assessment of the project risks and hazards associated with UAV flights, KSC will establish flight safety review requirements that are commensurate with the degree of risk identified.

SPECIAL INTEREST ITEMS

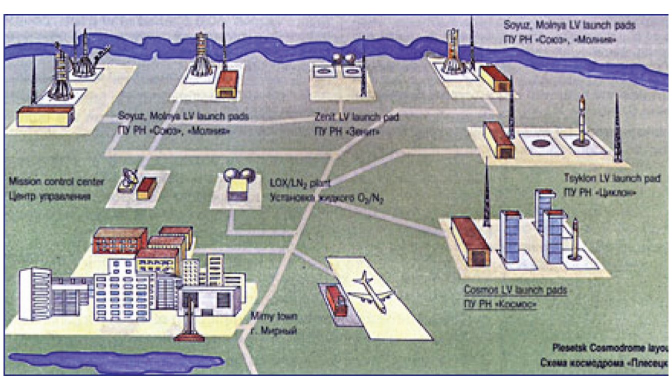
RUSSIAN LAUNCH FAILURES

In the space of twenty-four hours, the Russian launch industry suffered two launch failures. On 21 June 2005, a Molniya-M rocket carrying a military communications satellite and a Volna rocket carrying a US-sponsored solar sail both failed before placing their payloads in orbit.

Molniya-M Failure

Early on the morning of June 21, Russian Space Forces conducted the launch of a 315-ton Molniya-M rocket to place a Molniya-3K military communications satellite into what was presumed to be a highly elliptical orbit that could have reached as high as 25,000 miles. The launch was conducted from the Plesetsk Cosmodrome in far northern Russia. The spacecraft was expected to reach orbit approximately 53 minutes later, but it never established communications with ground control.

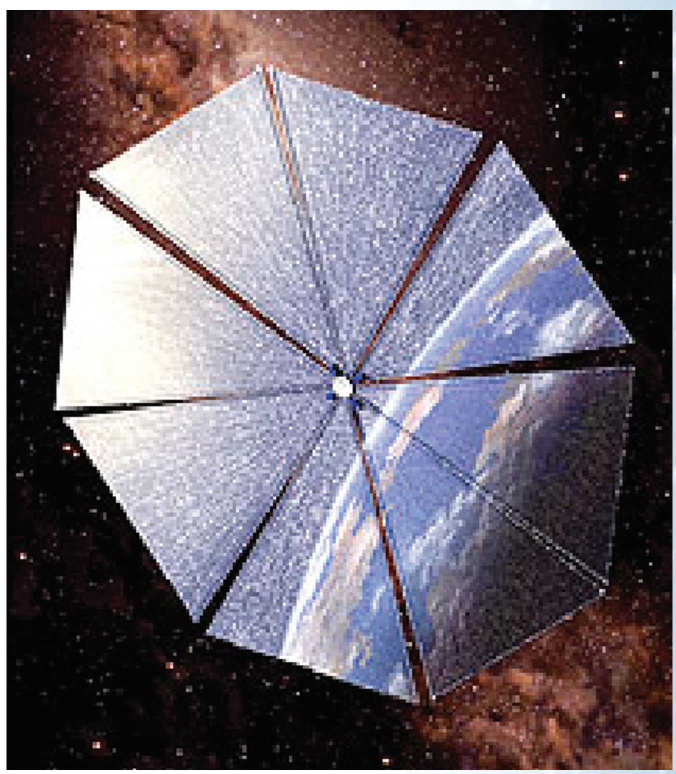
A review panel made up of Space Forces, the Federal Space Agency Roskosmos, and Russia's leading space enterprises and research institutes, reportedly determined that the rocket crashed as a result of excessive fuel consumption by the second-stage engine, leading to its destruction. The flight of the Molniya-M ended approximately six minutes after launch. The vehicle and its payload made impact in the Uvat region of the Tyumen Oblast, a relatively unpopulated region of western Siberia. No injuries on the ground were reported and the environmental impact appeared to have been minimal since the main fuel components are kerosene and liquid oxygen.



The Molniya-M launch vehicle is basically a Soyuz launch vehicle with an additional third stage. The Molniya-M was originally developed for lunar and planetary missions, but it is now used to place payloads of 1.6 to 1.8 metric tons into orbit. This launch vehicle, with a length of 138 feet and a diameter of 8.9 feet, has been among the most reliable space launchers currently in service according to the manufacturer, TsSKB Progress.

Volna Failure

Later on the afternoon of June 21, a Volna rocket was launched near Murmansk in the Barents Sea from the K-496 Borisoglebsk, a Kalmar class submarine. The Volna, carrying the Planetary Society's Cosmos 1 solar sail payload, failed because of a premature



©Planetary Society, Credit: Rick Sternbach

shutdown of the first-stage engine. According to the failure review board, made up of representatives from the Makeev Rocket Design bureau, the Lavochkin Association (which built Cosmos 1), and Tsniimast, a lead engineering design center of Roskosmos, the engine stopped firing at approximately 83 seconds into the flight as a result of the degradation in the operation of the engine turbo-pump.

The review board also noted that the first and second stages never separated so the Cosmos 1 orbit insertion motor did not fire and the spacecraft did not separate from the first stage. The Volna's on-board control system automatically aborted the mission 160 seconds into flight. In all likelihood, the payload and rocket fell into the Barents Sea.

The Volna, a launcher based on the R-29R submarine-launched ballistic missile—NATO designator SS-N-18/Stingray—has a length of 46 feet long and a diameter of 6 feet. It is designed to launch small spacecraft, with the warhead section used to accommodate the payload. A small rocket engine mounted in the payload section allows the injection of small spacecraft into near-earth orbits.

CONSTELLATION (CX)

Going to the Moon and Beyond

Before 2020, NASA astronauts will again explore the surface of the Moon where they will build outposts and pave the way for eventual journeys to Mars. The journey begins with the development of a new space exploration system that is affordable, reliable, versatile, and safe. The centerpiece of this new system is a new crew exploration vehicle (CEV).

The Crew Exploration Vehicle

The CEV is a spacecraft designed to carry four astronauts to and from the Moon, support up to six crew members on future missions to Mars, and deliver crew and supplies to the International Space Station. The new CEV is shaped like an Apollo capsule, but it is three times larger.

The high tech design combines the very best of the original Apollo and the Space Shuttle. Although the new CEV may have an Apollo shape, the new spacecraft will have significant advances, including:

- Modern materials and manufacturing processes
- Advanced avionics
- Computer systems and the knowledge gained from 40 years of human flight
- Increased volume to carry a larger crew and move cargo
- Improved operational efficiency and overall capability
- The ability to parachute to a ground landing

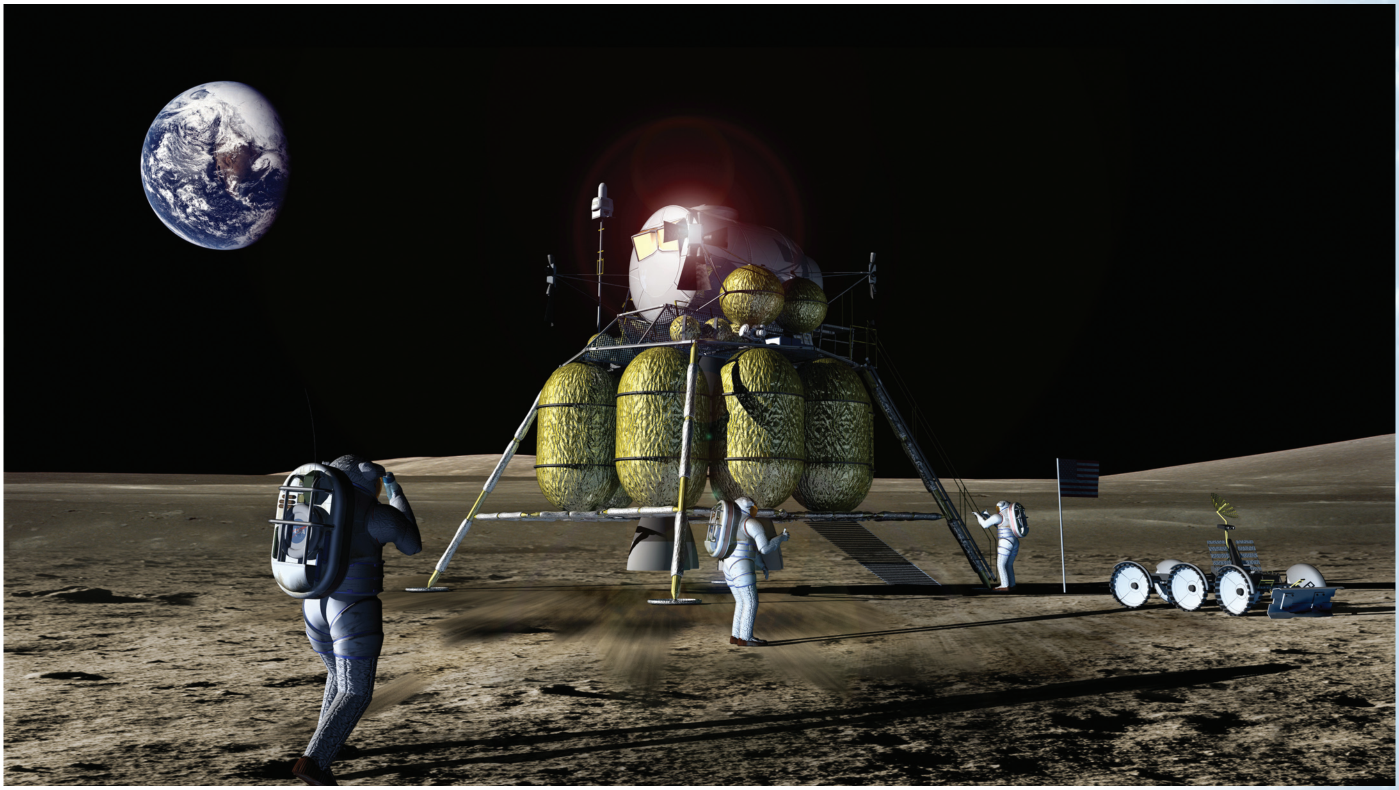
Powered by solar panels and currently considering the use of a liquid methane engine, the capsule shape allows the heat shield—the main thermal protection system—to be protected until it is needed for reentry. The capsule shape is more stable aerodynamically for nominal auto-guided entries and emergency aborts. The new CEV can be used up to 10 times.

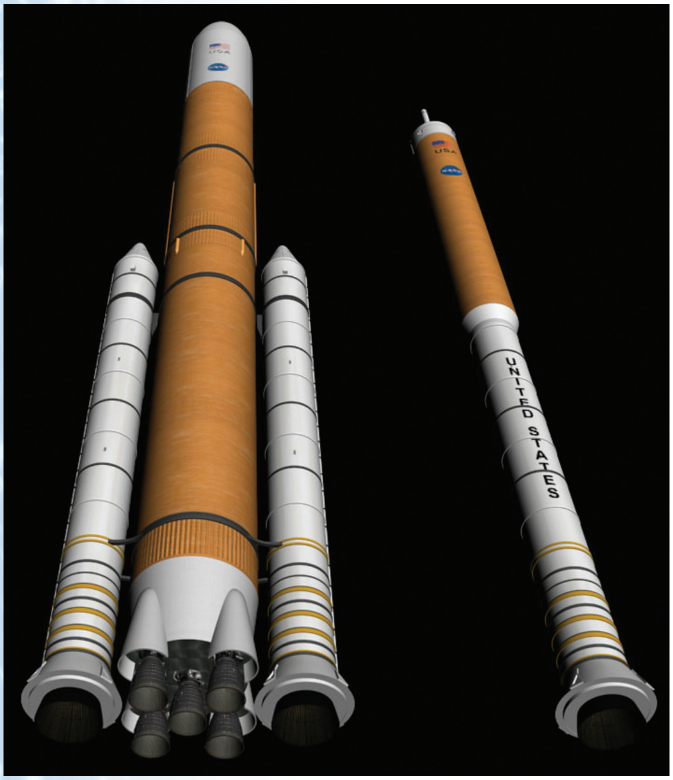
In just five years, the CEV will ferry crews and supplies to the International Space Station with as many as six trips to the outpost each year.

The Lunar Lander

Just as the CEV is similar to the Apollo spacecraft of the past, the lunar lander or lunar landing module is also similar to the one used by astronauts to reach the surface of the Moon 35 years ago. However, these landers will be bigger. The lander is attached to a rocket booster that is fired once the CEV connects to the lunar landing module in low Earth orbit. Firing the rocket booster sends the CEV and the lunar lander out of Earth orbit and toward the Moon.

Where Apollo landing sites were limited to the Moon's equatorial regions, the new lunar lander is able to reach any point on the lunar surface, including the poles. Four astronauts, rather than two, will be able to explore the Moon and spend up to a week, rather than a couple of days, on its surface.





The Launch System

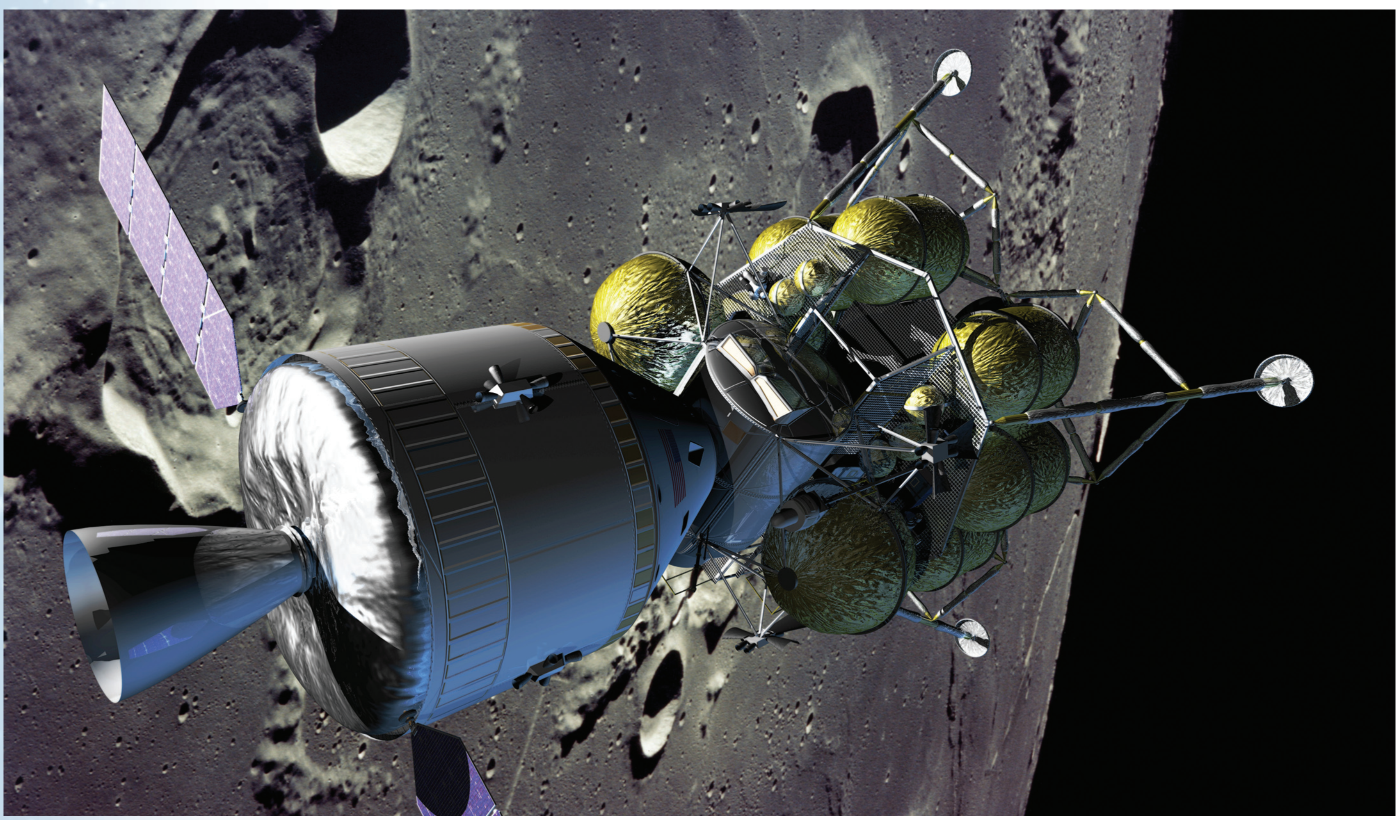
After studying a variety of options, NASA chose a shuttle-derived option for the launch system because of its superior safety, cost, and schedule availability.

The launch vehicle for the CEV is a single, four-segment, solid propellant rocket booster with a liquid oxygen/liquid hydrogen upper stage supporting one shuttle engine. This configuration can lift 25 metric tons.

The launch system for the lunar lander consists of five shuttle main engines and two, five-segment, solid propellant rocket boosters, yielding a lift of 106 metric tons to low Earth orbit and 125 metric tons if using an Earth departure stage.

CEV Safety

With vision comes change and with change come new processes, policies, procedures, and requirements. In every facet of the CEV program, there is one overarching requirement: Safety! New CEV requirements documents will provide the critical guidelines and procedures necessary to ensure all aspects of launch operations are conducted safely. With that in mind, the fluid nature of bringing a new system to life will create many challenges for NASA, the Department of Defense, and the numerous contractors involved in the design, production, testing, reliability, and eventual launch of the CEV.



One such challenge for Range Safety is the determination of flight termination system requirements for the CEV. Currently, the Shuttle has a flight termination system only on the solid rocket boosters, but expendable launch vehicles have a flight termination system on all stages, including the solid rocket motors.

- Will the CEV flight termination system be similar to the ones used on expendable launch vehicle systems or will there be a new and distinctive configuration?
- Will linear-shaped charges be extended to the aft segment of the solid rocket boosters?
- Will emerging technologies, such as the enhanced flight termination system or the autonomous flight safety system, be considered for use?
- What will be the requirements/procedures for mission abort and termination of the launch vehicle once the crew capsule is jettisoned?

These are just a few of the critical flight termination system questions Range Safety must be able to answer to ensure public safety.

Whether it is a question of the type of flight termination system to be used or the conduct of a risk analysis to ensure public and workforce safety, the Constellation Program Office and Range Safety are committed to ensuring the Constellation family of vehicles are the safest and most reliable launch vehicles to ever launch from KSC.

WINNING THE ANSARI X-PRIZE

On 4 October 2004, SpaceShipOne claimed the ten million dollar Ansari X-Prize, formerly the X-Prize, when it reached 100 kilometers, about 62.5 miles above the earth, for the second time in a two-week period. At the same time, SpaceShipOne erased the 41-year-old record for winged aircraft held by the X-15.

The Ansari X-Prize was created in 1996 by the X-PRIZE foundation. Criteria for winning the prize included the following:

- A team would have to privately build, launch, and finance a vehicle capable of carrying three passengers (or one passenger and ballast to equal the weight of three) to 100 kilometers and safety return to earth.
- The same vehicle would have to repeat the flight twice within two weeks.
- No more than 10 percent of the vehicle's non-propellant mass could be replaced between the first and second flights as a demonstration of economic reusability.

SpaceShipOne

SpaceShipOne —constructed of composite materials—was funded by Paul G. Allen, designed by Burt Rutan, and built by Rutan's company, Scaled Composites. It cost approximately thirty million dollars to produce. On its first flight conducted on September 27, SpaceShipOne reached a maximum altitude of 337,500 feet with a motor burn lasting 77 seconds. The second flight attained a maximum altitude of 377,591 feet with a motor burn lasting 84 seconds, setting the new record.

Like the X-15 of the 1960s, SpaceShipOne uses an air-launch system. At a predesignated altitude of just under 50,000 feet, SpaceShipOne launches from its carrier vehicle (White Knight) and proceeds on its suborbital path. The cocking tail section allows deceleration to happen at a higher altitude, reducing stress and heat on the vehicle.

Photo Credit: Scaled Composites—taken from Dryden Flight Research Center Express

SpaceShipOne is a lifting body propelled via rocket after launch and uses a non-powered re-entry. The fuel combines nitrous oxide as an oxidizer and hydroxy-terminated polybutadiene (rubber). The propulsion system is called a hybrid rocket system because of this fuel combination. At approximately 150,000 feet, the motors stop burning and the craft coasts until it reaches apogee. At that point, the back of the craft's wings fold upward to increase drag and slow the airplane as it falls through the second half of its parabolic flight.

During the flight, personnel from Dryden Flight Research Center and the US Air Force provided assistance to the mission. Dryden's Western Aeronautical Test Range provided radar-based, time-space positioning information to the Air Force which was contracted to provide tracking services for SpaceShipOne's flight.

The X-15

The X-15—the most remarkable of the rocket research aircraft and predecessor to SpaceShipOne—was a joint program operated by NASA, the Air Force, the Navy, and North American. With a technical approach somewhat similar to that of SpaceShipOne, the X-15 used an air launch system with a modified Boeing B-52 Stratofortress as its launch vehicle. Composed of an internal structure of titanium and a skin surface of a chrome-nickel alloy known as Inconel X, the X-15 was fueled by liquid oxygen and a non-cryogenic fuel (anhydrous ammonia).

Three X-15s were built. Among them, they completed 199 flights from 1959 to 1968. The X-15 program saw the same vehicle launch twice during a two-week period on 38 separate occasions during its testing period. On 10 occasions, the program sent the same vehicle up twice in under a week. From April 30, 1962 until August 22, 1963, the X-15 set three consecutive altitude records. The last—354,200 feet set on August 22, 1963—remained unbroken until the flight of SpaceShipOne.

The X-15 provided an enormous wealth of data on hypersonic air flow; aerodynamic heating; control, and stability at hypersonic speeds; reaction controls for flight above the atmosphere; piloting techniques for reentry; human factors; and flight instrumentation. This data contributed to the development of the Mercury, Gemini, and Apollo piloted space flight programs as well as the Space Shuttle program.

SPENDING A YEAR WITH THE 45TH SPACE WING

by Roland Schlierf, ISS Utilization Project Engineer, KSC

If NASA were to give you the opportunity to work a year-long assignment outside of the agency in an effort to broaden your experiences and skills as a NASA leader of the future, where would you go? That is exactly what NASA challenged me to determine as a member of this year's Leadership Development Program. I looked at a number of different options, but it was not until I met with Mr. Peter Taddie, Chief Engineer of the 45th Space Wing Office of Safety, and discussed the Range Safety "Concept to Launch" process that I made up my mind. In this article, I share some of my experiences, insights, and perspectives as a NASA leader who was given this unique opportunity.

Keeping the Columbia Accident Investigation Board report in mind, a primary goal of this assignment was to take a seasoned NASA engineer like myself from the engineering ranks and significantly increase my safety awareness and safety engineering competence for the future. Another primary goal was to become deeply imbedded in another culture, in this case the Air Force culture, while at the same time experiencing the NASA culture from an outside perspective.

Safety Awareness and Safety Engineering

As I began working with the 45th Space Wing, I learned that for all launches off the Eastern Range, the 45th Space Wing has established a world class safety program. Led by Colonel David Nuckles, the Space Wing's well trained professionals ensure safety compliance for all of these launches. Safety criteria include mission planning documentation, waivers, meets intent certifications, launch requirements, flight plan approval, launch commit criteria, mission rules, and a final recommendation to the launch decision authority to proceed to launch from a safety perspective. Their tireless efforts protect lives and property by providing outstanding risk management.

Additionally, Space Wing personnel provide safety for all operations at the Eastern Range, including flight termination systems, explosives, blast and toxics, and hazardous and safety critical system review while holding true to their vision to exceed customer expectations by providing responsive, timely, reliable, and cost-effective safety support. Another group reviews plans and specifications for new construction, major building alterations, and/or changes in installation equipment and monitors the project through completion to ensure compliance with safety codes and standards.

Since before the days of Apollo, the 45th Space Wing has provided this kind of consistent top quality range safety engineering to NASA for Shuttle, expendable launch vehicle, and related payload launches and landings. United in mission and reinforced by the "Webb-McNamara" agreement, NASA and the Air Force continue to work together as much as possible to provide maximum mutual assistance and minimum duplication. We plan to successfully continue our business in this way for many generations to come. This Leadership Development

Program assignment was yet another important step in this on-going critical partnership as we march with the 45th Space Wing in support of our agency's "Vision for Space Exploration."

The Air Force Culture

With my new found colleagues, I daily embraced and lived the Air Force primary value of "Integrity First." There is a serious and incredible awareness that we are a nation at war, while at the same time, there is time made for the lighter side. "Battle" language and imagery is often used throughout the day even when the subject matter and environment are not really hostile. There is a strong internal bond. However, this strong internal bond is nicely mixed with a sense of a true desire for inclusion. For example, despite significant on-going range safety discussions between NASA and the Air Force in the weeks just before my arrival, I was made to feel welcome and was quickly taken in.

Trust increasingly began to build between us, and soon all of the various team members and senior leadership were including me in their daily technical and political struggles and successes as I shared related NASA experiences and insights. I suspect that the Air Force/NASA relationship probably works that way across many of our fronts, so I see much hope and value in our continuing to partner in our business dealings and space adventures.

As in NASA, there is also a genuine desire for a "One NASA" like mentality and supporting behavior in the Air Force. To that end, my experiences in the 45th Space Wing Office of Safety were very much like my experiences in the NASA Spacelab and Space Station organizations because they all were and are filled with well educated and experienced, "hands-on," fully engaged engineers, both civil servant and contractor, with high energy "can do" attitudes. They know they can get the job done while keeping in mind that there is always another option to explore while meeting hard requirements, tailoring others, and diligently waiving what can be responsibly waived. After these experiences, I would assert that we have much more in common and much more to celebrate than not.

Other Areas with NASA Ties

In addition to achieving these high level goals, I worked several other specific, exciting areas that have strong NASA ties.

Quest for Successful Launch Attempts

Early in my assignment, I worked four launch attempts from the Range Operations Control Center range safety console. One of these was the successful Atlas V launch with the NASA Mars Reconnaissance Orbiter payload on board. Not surprisingly, the three scrubs proved invaluable for learning. During the scrubs, our safety console worked several important range safety issues:

- Tracking and clearing a ship from the danger area
- Clearing excessive personnel from a dangerous area
- Flight termination system battery and command receiver decoder technical issues
- Weather balloon temperature inversion issues that affected blast and toxic calculations for Port Canaveral
- Composite overwrap pressure vessel safety critical cycle issues and related follow-on personnel access safety concerns

All of this made it clear to me that we all want to launch and move forward, but only after all of the risks have been understood, weighed, mitigated, or accepted responsibly.

Quest for Best Practices

NASA has asked the Air Force to help in the development of the new Expendable Launch Vehicle Payload Ground Safety Review Process NASA Procedural Requirements Document with the goal of incorporating Air Force "best practices" in the NASA process and making our processes across all of our centers and all the affected agencies as consistent as possible for us and our customers. On a related note, it became obvious to me that we are all becoming increasingly aware that we are in competition for business regionally, nationally, and internationally.

During this assignment, I recognized that we have many management and technical issues in common, and that we also have many resolution tools and techniques in common. It is through our critical partnership and sharing of best practices and ideas that we achieve even more outstanding performance across both of our organizations. This was exactly the kind of important common ground and "best practices" collaboration that I was seeking as one of my goals during this assignment with the Air Force.

Quest for Future NASA Involvement

The Florida Space Authority, Florida Tech, Embry Riddle, and the 45th Space Wing engaged in a visionary meeting about the "Pioneer Cup" competition where colleges would compete in the development and launch of small rockets and payloads to a pre-selected location. It was exactly the kind of senior visionary leadership meetings that I know NASA's Leadership Development Program is all about. I found it interesting that NASA was not part of this project, but NASA may be in the future and I worked some side projects to that end.

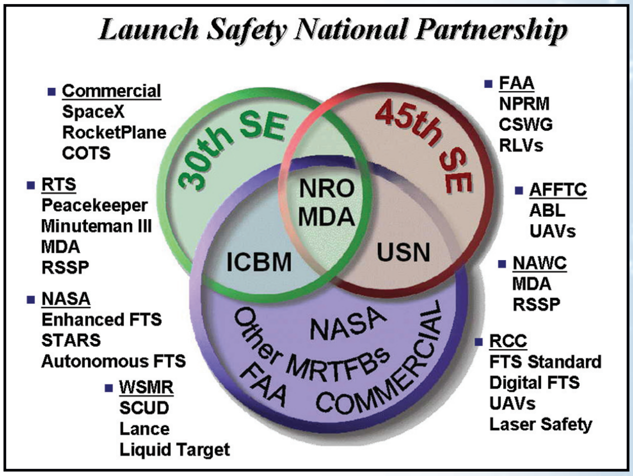
Quest for New Vehicles

Kistler executives met with the 45th Space Wing on the progress and future of potentially launching and landing their rocket from the Cape. Coming from a Space Station organization, I find Kistler very interesting because their executives talked about the potential for significant payload down mass from station which would be a huge boost in the arm for a potentially significant increase in station science, a topic that is very near and dear to my heart. The reusable vehicle is proposed to be turned around very quickly. The concept also has very interesting range safety issues because it returns vehicles to the launch site.

Looking to the Future

In conclusion, these new colleagues at the 45th Space Wing are very competent engineers who are open, honest, and hold very little back. From them, I received genuine support and excitement about NASA; our new NASA Administrator, Mike Griffin; and what he, along with the rest of us, are doing to implement our vision for space exploration.

It appears to me that achievement of this vision will take a measured blend of the old and the new—both in people and technologies. As my mentor and friend Mr. Peter Taddie so aptly told me, it looks like we are all going "back to the future." NASA's Leadership Development Program is about taking the time to develop the people who are going to help lead and create that new future. I would be very pleased if that future ends up with me once again working with the fine people I have met at the 45th Space Wing.



CHINA'S SPACEFLIGHT SUCCESS

China's fledgling manned space program has been in development for more than a decade, with its first unmanned prototype successfully launched and recovered in 1999. Following four successful unmanned space flights of its Shenzhou-series spacecraft, China's historic first manned mission was launched in October 2003, making it the third nation to put a human into orbit behind the former Soviet Union and the United States.

On 12 October 2005, China successfully conducted its second manned space launch aboard the Shenzhou 6 capsule atop a Long March-2F rocket. The mid-morning launch occurred from the remote Jiuquan launch site, in northwest China's Gansu province at the edge of the Gobi desert.

The Astronauts

The astronauts for China's first two-man mission, Fei Junlong and Nie Haiheng, are both former pilots in the Chinese Air Force. Additionally, Fei and Nie were part of the original group of fourteen astronauts training over the past few years for the opportunity to fly in space on the Shenzhou 6. They have been members of the astronaut brigade of the People's Liberation Army since 1998. During their five-day mission, the pair conducted a regimen of life science experiments and other unspecified activities.

The Equipment

Although the Shenzhou 6 is modeled after the Russian Soyuz, it is considered much safer due to a number of technological advances to the launch vehicle and the launch escape system, deemed critical following the Columbia disaster. In addition, over 110 technical modifications had been made to the spacecraft design for the 2005 flight.

The improved launch escape system allows the crew to escape the pod before liftoff via cables, high-speed elevator, or ejection seats. The escape tower can fire to pull the capsule and orbital module away from the booster in the event of a major booster malfunction from 15 minutes before launch to the point of escape tower jettison at approximately T+120 seconds. The escape tower can be activated automatically by the fault monitoring system or by ground control or manually by the astronauts. Additionally, the escape pod is equipped with improved life-support systems for the crew.

The Long March-2F consists of two core stages, a payload fairing, an escape tower, and four, liquid-fuel, strap-on boosters. The rocket has improved guidance and control equipment, upgraded engines, a fault monitoring management system, and its craft shell has been reinforced to withstand greater extremes of heat and vibration.

The Future

The successful parachute return, in the northern China province of Inner Mongolia, is the first part of the next step in China's methodical space development plan. Senior officials have revealed that the Shenzhou 7 is currently expected to launch next year to perform the program's first spacewalk, and that Shenzhou 8 could rendezvous and dock with the orbital module left in space by Shenzhou 7 as early as 2008. China's long term plans call for a manned space station and more ambitious missions in the next decade.

LIGHTNING LAUNCH COMMIT CRITERIA (LLCC)

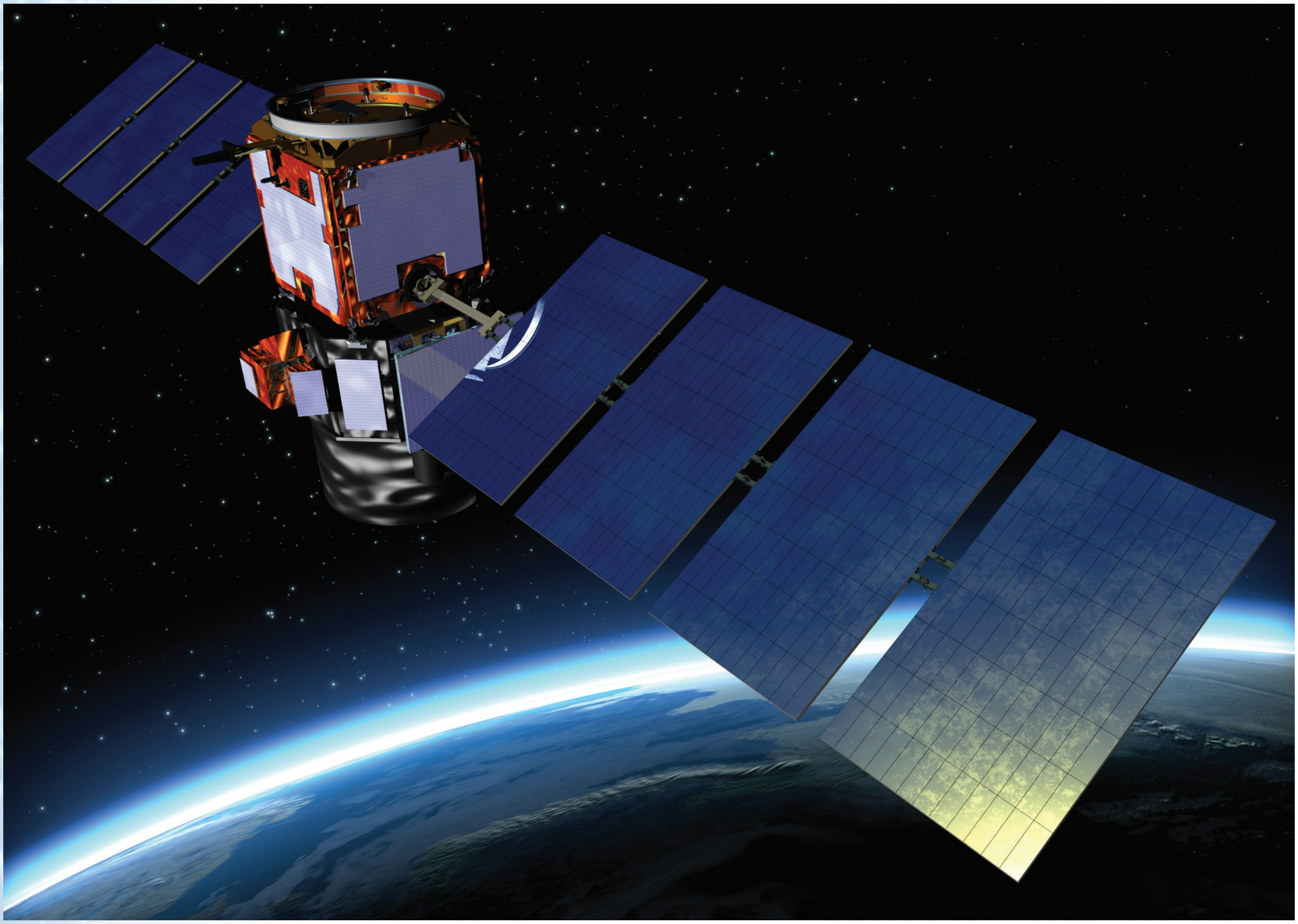
Lightning triggered by a vehicle's flight is poorly understood and dangerous. Apollo 12 was struck twice by triggered lightning during its 1969 launch. Only robust backup systems saved the mission from disaster. In 1987, triggered lightning destroyed Atlas Centaur 67 during ascent. These accidents emphasized how little was understood about observing and forecasting the conditions which create triggered lightning, and resulted in 11 complex and restrictive lightning launch commit criteria (LLCC). To improve the LLCC to ensure mission success but not unnecessarily delay or scrub missions, NASA initiated a series of triggered lightning research programs. This research has driven a series of LLCC revisions which Department of Defense (DoD), Federal Aviation Administration (FAA), and most American private companies have adopted. To guide the research and recommend LLCC revisions, NASA and the Air Force formed the Lightning Advisory Panel (LAP) consisting of America's best atmospheric electricity experts.

A major LLCC revision was implemented during 2005 based on research conducted during 2000 and 2001. An aircraft was instrumented to directly measure electric fields aloft and cloud particle sizes, density, composition, etc. associated with the fields. Other sensors included the CCAFS/KSC network of 31 ground based field mills and two lightning detection systems, the Patrick AFB 5cm radar, and the Melbourne National Weather Service 10cm Doppler radar.

The data were rigorously quality controlled, calibrated, aligned, and synchronized. The master database was located on the National Center for Atmospheric Research website which allowed all participating scientists access and the ability to jointly discuss and collaborate on the subsequent analyses Proposed LLCC changes were developed during numerous telecoms from 2001 to 2005. The database is now archived on a KSC website.

Based on early analyses, the LAP recommended the LLCC's radar threshold for cloud edges, tops, sides and bottoms be changed from 10 dBZ to 0 dBZ. Launch programs implemented the change immediately to ensure flight safety. Later, more detailed analyses of cloud-physics data showed 0 dBZ closely agreed with visible cloud edges.

The analysis team focused on the thunderstorm anvil LLCC. A reliable relation between radar and electric field data was achieved with a quantity called Volume Averaged Height Integrated Radar Reflectivity (VAHIRR). If specified VAHIRR thresholds are satisfied, the revised LLCC allow safe relief from the "do not fly through or within 5 nautical miles" anvil rules. VAHIRR is a product of two quantities computed everywhere along the flight track: the average radar reflectivity (dBZ) of cloud in a volume horizontally centered on point of interest and the average cloud thickness above the freezing level within the specified volume. There are limitations--VAHIRR is not valid if any significant part of the volume is not scanned by the radar or is affected by attenuation or non-meteorological echoes. While ensuring flight safety, VAHIRR permits flight through or near anvils from distant thunderstorms. Initial rough estimates are that the changes will reduce the false alarm rate for anvils from ~ 90% to ~ 60%. The LLCC changes have been adopted by NASA, the Eastern and Western Ranges, the FAA, and Expendable Launch Vehicle (ELV) programs.



NASA EXPENDABLE LAUNCH VEHICLE SAFETY PROGRAM

NASA-STD-8719.8, NASA Expendable Launch Vehicle Payload Safety Review Process Standard, 1998 documents the payload review process for Expendable Launch Vehicle (ELV) payloads. As part of the process, the standard requires a Payload Safety Working Group for each payload. The standard is outdated and problems have been encountered on particular projects involving multiple NASA Centers or international partners where conflicting requirements were not able to be resolved. To solve these shortcomings, the NASA Headquarters Office of Safety and Mission Assurance established a Program Development Working Group in 2004 to update the ELV payload safety review process and replace the current NASA standard with a NASA policy directive and a NASA procedural requirements document.

Key Features of the New Program

An Executive Team was appointed to organize and facilitate the working group activities, to coordinate with external organizations, and to ensure consistency with current NASA independent technical authority implementation. The Executive Team consisted of members from Headquarters, Goddard Space Flight Center, the Jet Propulsion Laboratory, and KSC Safety and Mission Assurance organizations and held its first meeting in March 2005.

The team's goal was to develop a program with improved structure and processes for ensuring NASA ELV payloads are designed, transported, processed, tested, integrated with the launch vehicle, and launched safely. Key features of the new program include:

- A more formal approval process performed jointly with the Air Force approval process (for

launches from Air Force ranges)
- Consistent requirements and processes for all NASA ELV payloads
- Continuation of the Payload Safety Working Group and a phased safety review approach
- An ELV Payload Safety Panel to resolve conflicts, process waivers, and certify payloads are ready for shipment and launch

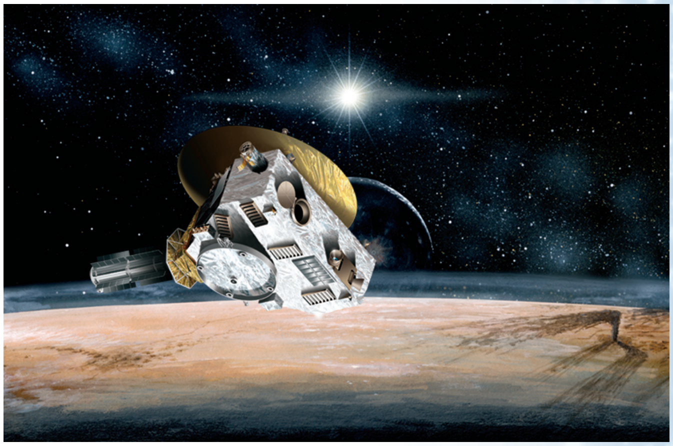
Current Status

A final draft of the NASA Policy Directive, NASA Safety Program for Expendable Launch Vehicle Payloads, was completed in December 2005 and is in the review cycle. An initial draft of the procedural requirements document was also completed in December 2005 and is being reviewed by the development team for final revisions. An interim NASA policy letter is being developed to kick off the new program in early 2006.

In addition to the new policy directive and procedural requirements document, an ELV Payload Safety Office will be established to implement the new program. This office will support ELV payload user operations and, jointly with NASA Headquarters, conduct independent assessments, surveys, and staff visits of NASA Centers and programs. The office will also participate in the Payload Safety Working Group, coordinate with the ELV Payload Safety Panel, and develop training courses for working group and safety panel members, as well as program managers and engineers.

PLUTO NEW HORIZONS MISSION

The Pluto New Horizons mission to Pluto and its moons was launched on January 19, 2006. Because of the distance between Pluto and the sun, the main power source for the spacecraft is a radioisotope, thermoelectric generator powered by plutonium. The picture at right shows the spacecraft and its generator. To ensure the safety of the launch support team, KSC employees, and the general public, a multi-agency taskforce was formed to develop the Pluto New Horizons Radiological Contingency Plans to minimize the chance of an incident and to mitigate any hazards resulting from an incident.



The taskforce consisted of members from KSC, NASA Headquarters, the Applied Physics Laboratory, the Jet Propulsion Laboratory, the Department of Defense, the Department of Energy, the Environmental Protection Agency, and federal, state and local emergency preparedness agencies.

The responsibilities of the taskforce, led by the coordinating agency representative—in this case, a KSC employee, included the following:

- Developing launch contingency scenarios
- Designing risk analyses associated with the launch contingency scenarios
- Developing and writing the Pluto New Horizons Radiological Contingency Plans based on the risk analyses
- Briefing the White House and other federal agencies on the contingency plans

- Briefing the Florida Governor and other state and local agencies on the contingency plans
- Briefing the public and the press on the contingency plans
- Performing emergency exercises per the plans
- Supporting spacecraft operations and launch activities

The team of over 60 support professionals from the agencies identified above assembled at KSC roughly a week before the launch. During this time, team members prepared monitoring equipment, tested modeling tools, and executed emergency exercises. On launch day, the team deployed to deal with any potential contingencies.

EVALUATING THE AREARAE GAS MONITORING SYSTEM

The NASA Aerospace Medicine and Occupational Health office is evaluating the use of a real-time gas monitoring system to supplement hydrogen chloride dispersion models generated for shuttle launches. The AreaRAE, manufactured by RAE Systems, Inc., is currently being evaluated. The monitoring system consists of a set of portable RF-linked hydrogen chloride gas monitors that can be deployed to selected launch viewing locations. The units operate in the license-free 902 to 928 megahertz range and transmit data to a centrally located base station within a two-mile range.

During the launch of STS-114, the AreaRAE units were used with some success. Hydrogen chloride measurements were remotely relayed to Environmental Health personnel supporting the launch. Additionally, the data from remote measurements were logged for post incident analysis. The expectation is that the units will provide real-time information to emergency response planners, enabling them to implement the best response strategy in the event of a shuttle accident. The same units, equipped with nitrogen dioxide gas sensors, may also be used for downwind monitoring during nitrogen tetroxide transfer operations for both shuttle and expendable launch vehicle fueling activities. NASA/KSC personnel are currently conducting field evaluations of the system to better understand the capabilities and limitations of the RF-linkage system. The units will be in place for the next shuttle launch.

STATUS REPORTS

KENNEDY SPACE CENTER

www.ksc.nasa.gov

KSC Range Safety Manager

NASA operates and uses ranges for the purpose of launching, flying, landing, and testing space and aeronautical vehicles and associated technologies. These activities often present hazards which can pose significant risk to life and property. It is NASA policy to mitigate and control the hazards and risks associated with range operations. To assist in these functions, all Centers are required to appoint a Range Safety Representative. In addition to keeping the HQ NASA Range Safety Manager informed of all activities related to range safety, the representative also provides the same office with an annual summary of all range safety activities associated with each program. Other primary duties include leading and/or participating range safety activities as designated by the Center Director or vehicle program manager and coordinating requests for any variance to a range safety requirement.

The current KSC Range Safety Manager has been very busy with a number of range safety related activities. He was a key player in three independent assessments. The first, February 05, was at Dryden's Range Safety Systems Office (RSSO) to review the findings and corrective action status from the previous assessment in 2002 and then evaluate the RSSO Flight Analysis Function. The second, in April 05, was at JSC to evaluate their plans regarding implementation of the draft policy and requirements of NPR 8715.5, Range Safety Program; and evaluate the public risk assessment tools used to determine the public risk levels incurred as a result of vehicle entry and support entry decision-making. Again in April, the KSC Range Safety Manager led a team to evaluate the adequacy of the Wallops Flight Facility (WFF) range safety ground systems supporting NASA missions. It included both the mobile assets as well as the fixed systems on WFF. A second objective of this assessment included reviewing the findings and corrective action status from the previous RSO assessment in 2002. He will also be part of a proposed contractor launch services audit in FY 06. Other range safety activities include:

- NASA POC to Range Safety Group – Presented RTF briefing and inputs to their Risk Committee
- Documenting approval of range safety non-conformances/variances for all applicable launches
- Coordinated on a KSC/AF MOU defining roles and responsibilities between NASA Range Safety and AF Range Safety
- Coordinated on development of a KSC Shuttle Program Contingency Action Plan.
- Key player in finalizing NPR 8715.5, "Range Safety Program"
- Participated in a myriad of SMA Readiness Reviews (SMARR), Launch Vehicle Readiness Reviews (LVRR), Flight Readiness Reviews (FRR), KSC's SMA Readiness Reviews (SARR) and numerous other launch related meetings
- Supporting all Shuttle and Expendable Launch Vehicle Range Safety Panel meetings
- Finalized a draft of Shuttle Launch and Landing Range Safety Risk Management Plan
- Coordinating with NASA (Shuttle program, SMA Director, Chief Legal Counsel and Associate Director) and Air Force (45 and 30 SW), to procure safety console positions in both AF Range Operations Control Centers for NASA launch operations
- Led a KSC team in developing the Shuttle Landing Implementation Plan that was in place for STS-114
- Spearheaded using the Self-Service Management Tool (SSMT) program to determine the location of KSC workforce during launch and recovery operations

These are just a sampling of the myriad of range safety functions routinely covered throughout the year. The KSC Range Safety Representative responsibilities have proven critical in safeguarding this Center's workforce, the general public and high value property.

WALLOPS FLIGHT FACILITY

1945 – 2005

60 Years Of Exploration

www.wff.nasa.gov

60 years of exploration

NASA Wallops Flight Facility 1945-2005

In 1945, Wallops Flight Facility (WFF) began as the Pilotless Aircraft Research Station under NASA's predecessor agency—the National Advisory Committee for Aeronautics. In 2005, Wallops celebrated its sixtieth anniversary. The past sixty years have seen NASA and WFF grow and evolve in the support of exploration, science, aeronautics, and education. This history has included the management and development of thousands of rocket, balloon, and aircraft systems, and the achievement of more than 16,000 launch operations, with an uncompromising focus on safety and a highly successful safety record.

Balloon Missions

During 2005, Wallops set a new long duration balloon flight record, when a balloon carrying the cosmic ray energetics and mass experiment flew for 42 days, circling Antarctica three times.

A new northern hemisphere, long-duration flight capability was also demonstrated with a balloon launched from Kiruna, Sweden, carrying the balloon-borne, large-aperture, sub-millimeter telescope payload in June 2005. The westerly flight lasted for 4.2 days and was terminated over Northern Canada.

New balloon systems and technological enhancements are also being pursued, including the development of the ultra long duration balloon system capable of extended duration, constant altitude flights at any latitude without the need for ballast. Numerous scaled model balloons have been fabricated and tested in the development program. A trajectory modification system that could make safe navigation around highly populated areas of the world is currently in the design stage.

The Balloon Office conducted 15 additional missions during 2005. The Wallops Safety Office was integral to each of these cutting-edge missions and technology efforts through its analyses and risk assessments.

Sounding Rocket Missions

The Sounding Rocket Program had a successful year, conducting 19 missions from WFF, White Sands Missile Range, Poker Flat Research Range in Alaska, and Hawaii. These missions involved NASA Space Science, educational outreach, and Department of Defense customers. The Wallops Safety Office supported these missions through mission analysis and operational support. Two vehicle anomalies were experienced this past year, and the Safety Office took part in the investigation and return-to-flight activities.

The Safety Office also supported the flight test of a new sounding rocket vehicle in June of this year as Alliant Techsystems (ATK) advanced solid axial stage completed its first flight demonstration from WFF. This newly developed rocket motor was flown in a two-stage configuration using a Terrier MK 70 booster as part of a Sounding Rocket Program technology initiative. While the motor was manufactured in the late 1990s as part of a since cancelled Air Force sponsored program, the vehicle combination proved to be successful.

Aerosonde Uninhabited Aerial Vehicle Missions

WFF also continued its use of the aerosonde small, uninhabited aerial vehicles (UAVs) for science research, as well as for demonstration to non-NASA customers. Among this year's highlights was a successful flight into Hurricane Ophelia in which the UAV took measurements at 500 feet altitude in Category 1 hurricane winds, the first such measurements ever taken and the first such use of a UAV. Aerosonde also continued to show its utility for homeland security applications during flights conducted from the WFF Research Airport and UAV runway.

Assumption of Responsibility for NASA's DC-8 Aircraft

The Wallops Aircraft Office assumed responsibility for NASA's DC-8 aircraft and transferred its operational activities to the University of North Dakota under a cooperative agreement in which the university will conduct earth science research flights for NASA. WFF safety, project management, and engineering personnel assessed North Dakota's safety program, facilities, and processes, as part of certifying the university to maintain and operate the DC-8.

Educational Outreach

The WFF Educational Flight Projects Office conducted over 100 projects involving 377 schools that brought 655 students to WFF. It also involved participation by nearly 200,000 students at their home institutions through NASA personnel visits and through the recently developed "Control Center in the Classroom" capabilities that allow virtual participation in flight hardware integration and launch operations via webcasting. The Wallops Safety Office developed and reviewed safety procedures that protected the students from the inherent risk of flight operations for rocket, balloon, and UAV projects

For the second year, WFF supported the National Federation of the Blind Jernigan Institute's "Rocket On!" Program. Twelve blind high school students had their hard work pay off with the successful launch of a rocket from WFF on July 21. The students were able to determine the readiness of their experiments and the rocket through audible signals. The 10.5 foot rocket flew to an altitude of 5,829 feet. Data was received on all four student-built sensors, which measured light, acceleration, temperature, and pressure.

Also in 2005, WFF's first International Space Station payload, the Space Experiment Module Satchel carried student experiments aloft on a Russian Soyuz flight and returned them on the Space Shuttle flight, STS-114.

Research and Technology Development

The WFF Research Range—consisting of the WFF Launch Range, Research Airport, and Mobile Range—conducted over 800 operations for NASA, other federal agencies, academia, and commercial industry in 2005. These operations included activities such as suborbital research rockets, hypersonics flight testing, Department of Defense targets, and Department of Defense missile and aircraft tracking exercises.

Mission and safety planning efforts continue for several upcoming major orbital spacecraft missions: the near-field, infrared experiment on a Minotaur 1 rocket in 2006 and the Defense Advanced Research Projects Agency (DARPA) Falcon flight demonstration missions of new small, low-cost, expendable launch vehicles.

The Research Airport supported Langley Research Center's aviation safety, noise, runway friction, and other similar research programs. It also supported various UAV platforms and commercial water ingestion testing. The Research Range continued its pursuit of next generation technologies that will streamline the cost and schedule of operations. Range Safety engineering expertise continues to heavily support these efforts to ensure that they effectively address critical safety concerns. Specific technology developments include:

The Global Positioning System Operational Information Laboratory

This laboratory is funded by the NASA Office of Safety and Mission Assurance and implemented by WFF. WFF will build a performance database of Global Positioning System receivers on launch vehicles and the tools to analyze the database in order to quantify performance, identify operational limits, and recommend areas of improvement.

Autonomous Flight Safety System

The autonomous flight safety system will provide a completely on-board safety system, using on-board navigation and a flight computer containing safety algorithms to assess the need for flight termination of errant or otherwise malfunctioning launch vehicles. When needed, the system will initiate actions to destroy the launch vehicle in order to protect the public. While focused on rocket systems, the system could also be applied to balloons, UAVs, or other flight systems, and could ultimately eliminate the need for costly ground-based instrumentation and personnel involved in real-time flight operations. Flight of a prototype system will occur during 2006.

Low-Cost Telemetry and Data Relay Satellite System Transceiver (LCT2)

The LCT2 is planned as a replacement for existing telemetry and data relay satellite systems for a fraction of the cost. NASA heavily relies on telemetry and data relay satellite systems in its most expensive and reusable flight systems. However, for its lower cost programs, particularly those in which the flight hardware is expended, the agency is looking at the LCT2. LCT2 will provide telemetry and data relay satellite systems capabilities at approximately $75,000 per unit, less than 20 percent of the cost of the current units.

Advanced Range Integrated Simulation Environment (ARISE)

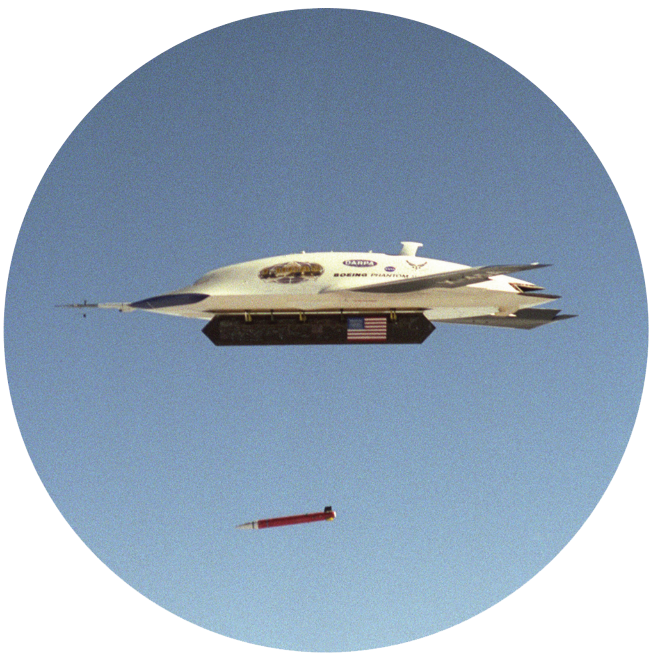
ARISE is a mission planning lab whose development serves as both a mission planning lab for designing trajectories and range support elements, as well as a technology simulator that encompasses the full spectrum of launch vehicle, range, and space-based resources involved in a launch operation. As a high-fidelity, hardware-in-the-loop simulator, ARISE will enable prototype hardware and software components of the vehicle or range to be laboratory tested for risk reduction before actual use in a space flight environment.

DRYDEN FLIGHT RESEARCH CENTER

www.dfrc.nasa.gov

The Dryden Flight Research Center, located at Edwards Air Force Base, California, is NASA's primary installation for flight research. Over the past 50 years, projects at Dryden have lead to major advancements in the design and capabilities of many civilian and military aircraft.

The center supports operations of the Space Shuttle and development of future access-to-space vehicles, conducts airborne science missions and flight operations, and develops piloted and uninhabited aircraft test beds for research and science missions. Dryden continues to support the testing of a wide range of uninhabited aerial vehicles (UAVs). The UAVs that were flown with Dryden assistance are described below.

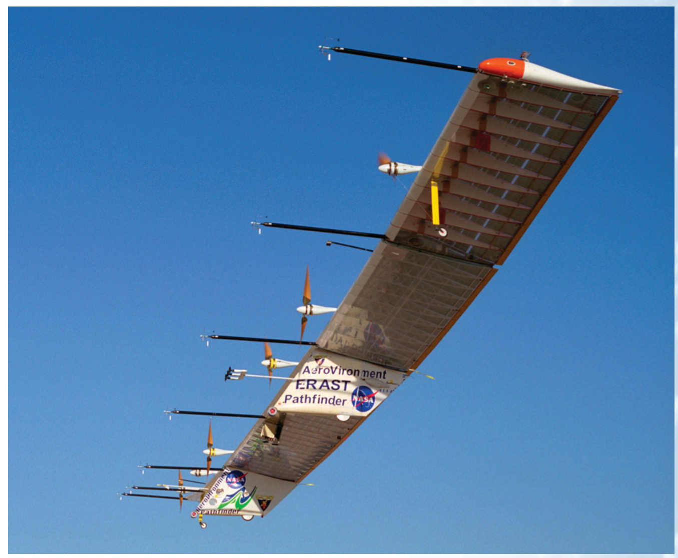


X-45A Unmanned Combat Air Vehicle

The Unmanned Combat Air Vehicle Program was a joint DARPA/Air Force/Boeing effort to demonstrate the feasibility for a UAV to serve in various front-line, combat support roles. The X-45A completed the final flight of the program in August of this year, successfully conducting 64 flights with two test vehicles.

Some highlights of the program included:

- Release of a Global Positioning System guided weapon
- Operation of two X-45A vehicles with a single operator
- In-flight transfer of operator control of two X-45A vehicles to a ground control station nearly 900 miles away
- Autonomous action of two X-45A vehicles to perform cooperative tracking, targeting, attack, and battle damage assessment on a set of simulated targets



Pathfinder Plus

AeroVironment's Pathfinder Plus successfully completed two flights in September, concluding the final flights ever of the Pathfinder Plus. The purpose of the flights was to collect information that will allow existing analytical tools to more accurately model atmospheric turbulence effects on large, low-stiffness, lightweight, high-aspect ratio composite structures.

Altair

General Atomics-Aeronautical Systems' Altair successfully completed two flights with NOAA scientific payloads in November. One flight lasted for 7 plus hours and the other for 18 plus hours. The purpose of the flights was to demonstrate the feasibility of a high altitude, long endurance UAV to conduct oceanic and atmospheric science missions.

Model-Type UAVs

The Networked UAV Project, in collaboration with NASA's Ames Research Center, used RnR Products' APV-3 to evaluate new flight-control software that will allow UAVs to autonomously react to obstacles as they fly pre-programmed missions. This technology may one day enable swarms of aircraft to move safely from one area to another as a flock or group.

The Sandia DART Project used Dryden's Utility Model to drop sensors developed by Sandia National Laboratory.

The Autonomous Soaring UAV Project used RnR Products' Cloud Swift sailplane to demonstrate that using thermal lift could significantly extend the range and endurance of model UAVs without a corresponding increase in fuel requirements.

Range Safety Office

Range Safety operations at Dryden are managed by the Range Safety Office, formerly the Range Safety Systems Office. The Dryden Center Director established the office, under an alliance agreement with the Air Force Flight Test Center, to provide independent review and oversight of range safety issues. The office also supports the center by providing trained flight termination system engineers, range safety risk analysts, and Range Safety Officers to provide mission and project support. In addition, the Range Safety Office supports the NASA Range Safety Training Program by providing the UAV perspective in the development of the Range Safety classes.

NASA HEADQUARTERS

www.nasa.gov

The Office of Safety and Mission Assurance (OSMA) at NASA Headquarters works to assure the safety and success of all NASA activities by developing, and overseeing the implementation of Agency-level policy and requirements related to safety, reliability, maintainability, and quality assurance. The NASA Range Safety Program functions as an element of OSMA. The OSMA approves and promulgates Agency-level range safety policies and requirements, designates the NASA Range Safety Manager, and funds and oversees Range Safety Program activities.

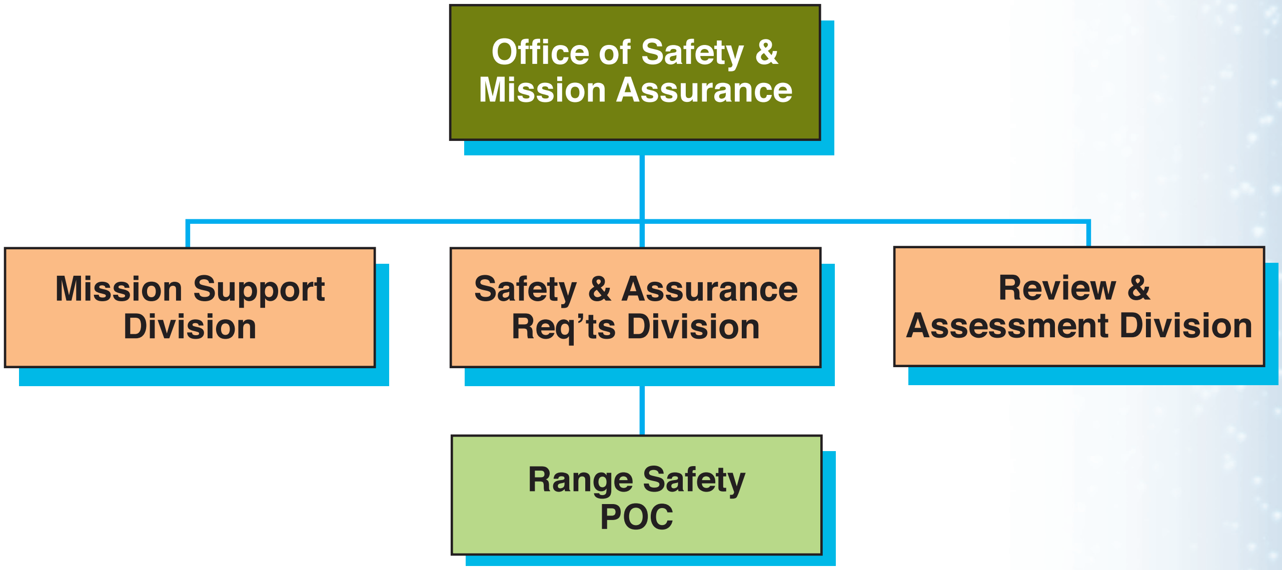
OSMA representatives worked regularly with Agency range safety personnel and participated in a number of range safety related projects and initiatives throughout 2005. The final development and approval of NPR 8715.5, *Range Safety Program* was a major accomplishment for 2005 that required extensive coordination between Agency range safety personnel and the OSMA. (The *Range Safety Policy* article of this annual report describes the NPR 8715.5 development effort and discusses key aspects of this new NASA policy and requirements document.) Other range safety related activities supported by or led by OSMA in 2005 include:

- **Expendable Launch Vehicle (ELV) Payload Safety:** The OSMA is leading an effort to develop a new NASA ELV Payload Safety Program. The OSMA has established a team of personnel with ELV payload safety expertise from throughout the Agency. This team is developing NASA policy and associated requirements applicable to launch processing and launch of ELV payloads, associated interface hardware, and ground support equipment used for payload operations. This new program will include a revised safety review and approval process applicable to all NASA ELV payload projects. *(see related article)*

- **Range Commanders Council (RCC):** OSMA representatives actively participated in semiannual RCC Range Safety Group (RSG) Main Committee meetings in 2005, and regular RSG Risk Committee meetings. *(see related article)*

- **Independent Assessments:** OSMA representatives teamed with NASA Range Safety Program personnel to conduct assessments of the range safety process and facilities at Dryden Flight Research Center and Wallops Flight Facility. The assessment team also performed a special review of the Space Shuttle Program's efforts at the Johnson Space Center to satisfy NASA range safety requirements for Space Shuttle Return-to-Flight. *(see related articles)*

- **Research and Technology Development:** The OSMA funds and oversees safety related research and technology development projects throughout the Agency. Range safety projects for 2005 included the Global Positioning System Operational Information Laboratory at Wallops Flight Facility, the Joint Advanced Range Safety System Project at Dryden Flight Research Center, and the Autonomous Flight Safety System Project at Kennedy Space Center and Wallops Flight Facility. *(see related articles)*



JOHNSON - SPACE SHUTTLE RANGE SAFETY PANEL

2005 was another busy year for the Space Shuttle Range Safety Panel. The panel was further involved in updating the Space Shuttle launch area and downrange overflight risk assessments along with the other tasks described below.

Updated Inputs for the Space Shuttle Launch Area Risk Assessment

During 2004, NASA Johnson Space Center engineers made a series of data deliveries to the 45th Space Wing to improve the inputs for the Space Shuttle launch area risk assessment. The assessment was further refined in 2005 through another series of analyses and data deliveries. One of the first improvements involved the simulation of trajectories for additional malfunction turn (off-course trajectory) failure modes that were identified using the Shuttle probabilistic risk assessment model. The trajectory data delivered in 2004 and 2005 consisted of more than 10,000 simulated failure scenarios. This analysis provided a dramatic improvement in the level of detail and accuracy for this particular aspect of the risk assessment.

Additionally, trajectory specialists worked with probabilistic risk assessment and subsystem experts to develop Shuttle first-stage, time-based failure probability distributions for use in the 45th Space Wing assessment. Supporting data and information regarding probabilistic risk assessment methodology were also provided to the 45th Space Wing. For instance, a thorough review of the failure rates for the Space Shuttle main engines was presented at the Range Safety Panel to support the selection of the time distribution for this failure mode. In addition, main engine test data was transmitted to the Space Wing so that an independent assessment of the failure probability distribution could be preformed. Through Range Safety Panel meetings, significant steps were taken to obtain a set of inputs for launch area risk assessment that can be mutually agreed upon by NASA and the Space Wing. In a cooperative effort with the 45th Space Wing, several launch area risk assessment inputs were reinvestigated. In addition to the areas previously mentioned, updates were made to the following launch area risk assessment inputs:

- First stage destruct and chevron lines
- Failure mode allocation
- Free flying solid rocket booster modeling

The comprehensive review of launch area risk assessment inputs during 2005 raised the level of confidence in the risk estimates for STS-114 and should serve as the cornerstone for future risk assessments during the remainder of the Shuttle program.

Updated Inputs for the Space Shuttle Downrange Overflight Risk Assessment

Marked improvements were made to several areas of the Space Shuttle downrange overflight risk assessment, which analyzes the risk to the public for failures during second stage ascent. Major updates were made to the following inputs:

- Trajectory data
- External tank debris catalog
- Orbiter/payload debris catalog
- Debris survivability data
- Failure mode probability data

Several thousand trajectories were simulated for nominal ascent, malfunction turn failures, and system and environmental dispersed cases. Downrange main engine cut-off lines were updated to reflect the new malfunction turn data.

Lockheed Martin's Michoud Assembly Facility expanded the external tank debris catalog to include pieces that were omitted in previous catalogs. The new catalog accounts for over 90 percent of the total mass of the external tank. Likewise, the entire orbiter debris catalog was reanalyzed to reflect the data obtained from the Columbia accident recovery effort. For both the external tank and orbiter debris catalogs, a debris demise assessment was performed to determine which debris pieces would survive to ground impact. The demise assessment had never been completed for any previous Shuttle public risk assessment and added another dimension to the overall risk model.

The final improvement to the risk assessment inputs involved the estimation of failure probabilities, which were then delivered to the 45th Space Wing. The Shuttle probabilistic risk assessment model was used to estimate the failure mode probability values and corresponding time distributions. Each of the input enhancements greatly increased the level of detail and accuracy of the downrange overflight risk predictions.

Range Safety Support of STS-114

The range safety community successfully supported the July 2005 launch of STS-114. Numerous analyses and flight product updates were completed in time for this Return-to-Flight launch. The newly reevaluated launch area and downrange overflight risks provided updated public risk estimates to support the launch. Products for STS-300—the rescue mission for STS-114—required unique trajectory designs and were also delivered to the 45th Space Wing in the event a Shuttle rescue mission was required. Range Safety Day-of-Launch operations were checked out before the STS-114 launch and executed successfully on launch day.

Range Safety System Frequency Change

The Shuttle Program Requirements Control Board disapproved a proposed plan to change the Range Safety System frequency used by the Space Shuttle. The plan was developed in response to a National Telecommunications and Information Administration directive, but was not approved due to cost and schedule impacts. Instead, a waiver through NASA Headquarters and the National Telecommunications and Information Administration will be negotiated and the panel will track the status of the frequency through the end of the Shuttle program.

"Trunking" Radio Interference

After vehicle rollout to the pad for STS-114, there were unusual spikes in the gain control for the Shuttle Range Safety System. It was determined that a "trunking" radio system, which was not widely used before STS-107, had significantly propagated throughout KSC during the Return-to-Flight time period. The trunking radio system's handheld receivers used by KSC personnel had a frequency band that coincided with the Range Safety System, causing potential interference. The panel investigated frequency options, but the trunking radio hardware cannot operate on a different frequency band. Measures to mitigate impacts, while maintaining all safety standards, were implemented through the panel and discussions with KSC will continue in the future. No impacts were identified to the STS-114 launch due to trunking radio interference.

RANGE COMMANDERS COUNCIL

http://jcte.jcs.mil/rcc/index.htm

Founded in 1951, the Range Commanders Council (RCC) is dedicated to serving the technical and operational needs of the United States test, training, and operational ranges. The council was organized to preserve and enhance the efficiency and effectiveness of member ranges, thereby increasing their research and development, operational test and evaluation, and training and readiness capabilities. Members include Army, Navy, Air Force, and Department of Energy (DOE) ranges.

The RCC provides a framework wherein common needs are identified and common solutions are sought, technical standards are established and disseminated, joint procurement opportunities are explored, technical and equipment exchanges are facilitated and advanced concepts and technical innovations are assessed and their potential applications identified.

As an associate member, NASA maintains active participation in the RCC and many of its working groups, including the following:

THE RANGE SAFETY GROUP

Through standardization, development, and continuous improvement, the Range Safety Group supports the safe conduct of hazardous operations on the test, training, and operational ranges and related facilities. Hazardous operations include, but are not limited to, ordnance and expendable releases, directed energy and laser operations, missile flight, space launch and entry, unmanned vehicle operation, gunfire, explosive use, and hazardous emissions.

Range Safety Group Meeting

The 97th meeting of the Range Safety Group was hosted by the Air Armament Center at Eglin Air Force Base, Florida in October 2005. NASA provided range safety related training status reports and range reports to the group for KSC, Wallops Flight Facility, and Dryden Flight Research Center. NASA also participated in reviews of new range related technology such as the subminiature flight safety system described below.

Subminiature Flight Safety System

The subminiature flight safety system is an Air Force led flight safety system being developed to meet all Range Commander Council 319-99, Flight Termination Systems Commonality Standard, and system safety requirements. The system is an integrated package consisting of two flight termination receivers, two flight termination controllers, and two safe and arm devices. The system uses Global Positioning System and telemetry data.

The objectives of the subminiature flight safety system are (1) to improve costs through one development effort and increased quantity; (2) improve scheduling with a qualified, integrated safety package, certified by the Range Commanders Council, and (3) and improve performance through testing with warhead variants at operational thresholds.

The proposed capabilities of the subminiature flight safety system are described on page 47.

- Support all types of weapons systems
  - Air-to-Ground
  - Air-to-Air
  - Surface-to-Air
  - Surface-to-Surface
- Meet Major Range Test Facility Base Range Safety specifications
  - Dual-redundant flight termination system
  - Time and Space Information System - provide weapon system position
  - Telemetry for providing system health and Time and Space Information System
  - High reliability (99.9 percent)
- Operate without tracking infrastructure
  - Water ranges
  - Long range weapons
- Be produced at a low cost (less than $35,000)

Currently the subminiature flight safety system is a phase one Central Test and Evaluation Investment Program. The developers are working with industry, government agencies, weapon system developers, and weapon evaluation groups to resolve current issues and obtain fidelity and confidence in the subminiature flight safety system concept by coordinating service commitment to use the system, completing systems engineering analysis, and developing requirements documentation for the Central Test and Evaluation Investment Program.

FLIGHT TERMINATION STANDING COMMITTEE

The NASA Range Safety Office fully coordinated the development of the Flight Safety System course with the Flight Termination Standing Committee. The course outline was presented in the April 2005 committee meeting, and the detailed course material was presented for review in the October 2005 meeting. Many changes and additions were made to the course material based on committee comments. Flight Termination Standing Committee members continued to assist with the course development up to and including the pilot course presentation.

THE RISK COMMITTEE

The Risk Committee, which evolved from the Risk and Lethality Commonality Team, is composed of primary and associate members, including personnel from the 30th and 45th Space Wings, NASA, Naval Air Systems Command, the Naval Air Warfare Center Weapons Division, the Pacific Missile Range Facility, the Reagan Test Site, and White Sands Missile Range. ACTA; 3D Research; Analysis, Planning, Test Research; Research Triangle Institute; SRS Technologies; System Test and Evaluation Planning Analysis Lab; and Tybrin provide technical support.

Changes to Original Risk Committee Objectives.

The Risk Committee weekly teleconferences and quarterly meetings have resulted in several changes to the committee's original objectives. The new objectives—listed below—will be incorporated into Range Commanders Council (RCC) Standard 321-02, ***Common Risk Criteria for National Test Ranges: Inert Debris*** and the associated supplement.

- Establish casualty criteria for all flight safety hazards
- Revisit fatality criteria to include all flight safety hazards
- Update and/or develop analytical processes for all flight safety hazards
- Determine the applicability and understand the consequences of a conditioned risk analysis for real-time flight termination criteria
- Define top-level characteristics for risk analysis models, including guidelines for articulating uncertainty in risk estimates

Modifications to RCC Standard 321 and the Associated Supplement.

The Risk Committee is actively working on RCC Standard 321- 02 and its associated supplement. To date, the group has selected an outline for the updated standard. The standard defines minimum acceptable requirements, including policy, risk criteria, and top-level flight safety processes. The supplement includes methodologies and examples of acceptable approaches for determining risk.

The first level of detail is described in Volume 1 of the standard and the second level of detail is incorporated in the supplement. The second level includes flow charts and checklists of considerations for each step in the risk assessment process. The committee has also concurred that the new standard should apply to expendable launch vehicles, missiles, and the launch phase of reusable launch vehicles.

Committee members are identifying options for defining risk criteria and developing a general policy statement for the development and selection of criteria. Sets of risk standards have been developed for committee review. The flight safety risk management program, a section of the standard devoted to risk associated with the missile once it is in flight, will be patterned after the system safety process.

Uncertainty in Risk Assessments

The committee also determined that uncertainty in the risk models must be acknowledged in the updated standard and they are defining the optimum approach to address this issue. To assist in evaluating the factor of uncertainty in risk assessments, the committee studied a legal review of uncertainty in risk assessments and risk litigation and found that, according to the review, the Constitution charges government with protecting the public welfare. As a result, Congress enacts laws to regulate activities in the public interest. For example, businesses may not impose unreasonable risks on their workers or the public.

In risk litigation, the role of science along with its uncertainty, has become a key issue. The regulatory and scientific communities lean toward a conservative upper bounds in assessing risk while civil courts require plaintiffs to meet only the preponderance or "more likely than not" standard of the Federal Tort Claims Act. In other words, according to the legal review, if one were to challenge an agency's action, one would have to prove that action either violated one of the agency's statutes or previously adopted roles or was arbitrary and capricious.

The issue of *uncertainty*, along with flight safety and risk management, continues to be addressed at the weekly teleconferences and quarterly meetings as the Risk Committee pursues a comprehensive, updated version of RCC 321 and its supplement.


NASA
Discovery

2005 LAUNCHES BY AGENCY

KSC Sponsored Launches

Date	Vehicle	Payload or Mission	Launch Location	Responsible Org
1/12/2005	Delta II	Deep Impact	CCAFS	NASA
5/20/2005	Delta II	NOAA-N	VAFB	NASA
7/26/2005	STS-114	ISS ULF-1	KSC	NASA
8/12/2005	Atlas V	MRO	CCAFS	NASA
10/26/2005	Pegasus	Dart	CCAFS	NASA

Eastern and Western Range Launches

Date	Vehicle	Payload or Mission	Launch Location	Responsible Organization
1/12/05	Delta II	Deep Impact	CCAFS	NASA
2/3/05	Atlas IIIB	NROL-23 MLV-15	CCAFS	NRO
3/2/05	Trident D-5	FCET 33	CCAFS	DoD
3/11/05	Atlas V	Inmarsat-4	CCAFS	DoD
4/11/05	Minotaur	XSS-11	VAFB	DoD
4/30/05	Titan IV B-30	NROL-16	CCAFS	NRO
5/20/05	Delta II	NOAA-N	VAFB	NASA
7/21/05	Minuteman III	inert	VAFB	DoD
7/26/05	STS-114	ISS ULF-1	KSC	NASA
8/12/05	Atlas V	MRO	CCAFS	NASA
8/25/05	Minuteman III	SERV 2	VAFB	DoD
9/7/05	Minuteman III	GT-187GM-1	VAFB	DoD
9/14/05	Minuteman III	GT-189GM / ALCS	VAFB	DoD
9/23/05	Minotaur	STP-R1	VAFB	DoD
9/26/05	Delta II	GPS IIR-14 (M)	CCAFS	DoD
10/19/05	Titan IV	B-26	VAFB	NRO
10/26/05	Pegasus	Dart	VAFB	NASA

Dryden Flight Research Center Missions

Date	Project Name	Mission	Location	Mission Result
1/12/2005 - 1/20/2005	Networked UAV	3 flights	Edwards AFB	Success
1/20/2005	X-45A AV2	Flight 13	Edwards AFB	Success
1/27/2005	X-45A AV1	Flight 33	Edwards AFB	Success[1]
1/27/2005	X-45A AV2	Flight 14	Edwards AFB	Success[1]
2/3/2005	X-45A AV2	Flight 15	Edwards AFB	Success
2/4/2005	X-45A AV1	Flight 34	Edwards AFB	Success[1]
2/4/2005	X-45A AV2	Flight 16	Edwards AFB	Success[1]
4/19/2005 - 05/17/05	Altair	6 test/check flights	Edwards AFB, Pt. Mugu NAS Sea Test Range, National Air-space System	Success[2]
5/13/2005	X-45A AV1	Flight 35	Edwards AFB	Success
5/26/2005	X-45A AV2	Flight 17	Edwards AFB	Success
6/03/2005 - 6/22/2005	Sandia DART Project	11 flights	Edwards AFB	Success
6/10/2005	X-45A AV2	Flight 18	Edwards AFB	Success
6/30/2005	X-45A AV1	Flight 36	Edwards AFB	Success[1]
6/30/2005	X-45A AV2	Flight 19	Edwards AFB	Success[1]
7/14/2005	X-45A AV2	Flight 20	Edwards AFB	Success
7/21/2005	X-45A AV1	Flight 37	Edwards AFB	Success[1]
7/21/2005	X-45A AV2	Flight 21	Edwards AFB	Success[1]
7/22/2005	X-45A AV1	Flight 38	Edwards AFB	Success[1]
7/22/2005	X-45A AV2	Flight 22	Edwards AFB	Success[1]
7/25/2005 - 9/15/2005	Autonomous Soaring UAV	17 flights	Edwards AFB	Success
7/28/2005	X-45A AV1	Flight 39	Edwards AFB	Success[1]
7/28/2005	X-45A AV2	Flight 23	Edwards AFB	Success[1]
8/10/2005	X-45A AV1	Flight 40	Edwards AFB	Success[1,3]
8/10/2005	X-45A AV2	Flight 24	Edwards AFB	Success[1,3]
8/31/2005	Pathfinder Plus	1 flight	Edwards AFB	Success
9/14/2005	Pathfinder Plus	1 flight	Edwards AFB	Success[4]

10/20/2005	Altair	1 test flight	Edwards AFB, Pt. Mugu NAS Sea Test Range, National Airspace System	Success
11/3/2005	Altair	1 functional check flight	Edwards AFB	Success
11/14/2005	Altair	1 flight	Edwards AFB, Pt. Mugu NAS Sea Test Range, National Airspace System	Success[5]
11/16/2005	Altair	1 flight	Edwards AFB, Pt. Mugu NAS Sea Test Range, National Airspace System	Success

[1] Multi-Vehicle Flight.

[2] Identified cold soak and over the horizon command and control link issues.

[3] Graduation Demonstration - Preemptive Destruction Suppression of Enemy Air Defenses.

[4] Final flight. Vehicle is retired.

[5] 18.4 hour flight.

Wallops Flight Facility Missions

Date	Vehicle	Location	Launch Result
1/4/2005	Test Rocket (6)	Wallops Island, VA	Success
1/19/2005	Test Rocket	Wallops Island, VA	Success
1/20/2005	Test Rocket (12.062 GT)	White Sands Missile Range, NM	Success
1/20/2005	UAV Aerosonde CG	Wallops Island, VA	Success
1/21/2005	UAV Aerosonde CG	Wallops Island, VA	Success
1/21/2005	Test Rocket (5)	Wallops Island, VA	Success
2/2/2005	Terrier-Orion (41.048 DR)	Kauai, HI	Success
2/4/2005	0.17 MCM Balloon (540N)	Ft. Sumner, NM	Success
2/15/2005	UAV Aerosonde	Wallops Island, VA	Success
2/16/2005	UAV Aerosonde	Wallops Island, VA	Success
3/1/2005	Terrier-Orion (41.049 DR)	Kauai, HI	Success
3/2/2005	Terrier-Orion (41.060 DR)	Kauai, HI	Success
3/3/2005	Terrier-Oriole (45.001 DR)	Kauai, HI	Success
3/3/2005	UAV Aerosonde GS	Wallops Island, VA	Success
3/4/2005	UAV Aerosonde GS	Wallops Island, VA	Success
3/6/2005	Black Brant XII (40.017 UE)	Poker Flat Research Range, AK	Failure[3]
3/7/2005	UAV Aerosonde	Wallops Island, VA	Success
3/15/2005	Orion (30.058 UE)	Poker Flat Research Range, AK	Success
3/15/2005	Orion (30.059 UE)	Poker Flat Research Range, AK	Success
4/11/2005	DAW-4322 BQM-74E	Wallops Island, VA	Success
4/11/2005	DAW-4323 BQM-74E	Wallops Island, VA	Success
5/3/2005	Test Rocket (4)	Wallops Island, VA	Success
5/5/2005	Terrier-Orion (41.057 DP)	Kauai, HI	Success
5/9/2005	1.1 MCM Balloon (541N)	Ft. Sumner, NM	Partial[4]
5/11/2005	SERI Student Rocket	Wallops Island, VA	Success
5/15/2005	UAV Aerosonde	Wallops Island, VA	Success
5/17/2005	Orion (30.056 UO)	Wallops Island, VA	Success
5/18/2005	1.1 MCM Balloon (542N)	Ft. Sumner, NM	Success

6/1/2005	1.1 MCM Balloon (543N)	Ft. Sumner, NM	Success
6/7/2005	0.3 MCM Balloon (544N)	Ft. Sumner, NM	Success
6/9/2005	Orion (30.061 NO)	Wallops Island, VA	Success
6/12/2005	1.1 MCM Balloon (545N)	Kiruna, Sweden	Success
6/18/2005	0.8 MCM Balloon (546N)	Ft. Sumner, NM	Success
6/28/2005	Test Rocket (12.060 GT)	Wallops Island, VA	Success
6/28/2005	Terrier ASAS (NRW-4231)	Wallops Island, VA	Success
7/7/2005	Black Brant IX (36.222 DS)	White Sands Missile Range, NM	Partial[5]
7/12/2005	DRW-4337 BQM-34S SEWP	Wallops Island, VA	Success
7/13/2005	DRW-4114 BQM-34S SEWP	Wallops Island, VA	Success
7/21/2005	NFB Student Rocket	Wallops Island, VA	Success
7/2-27/05	Aerosonde TCSP (8)	Costa Rica	Success
7/28/2005	0.8 MCM Balloon (1591P)	Palestine, TX	Success
8/3/2005	Black Brant IX (36.227 US)	White Sands Missile Range, NM	Success
8/28/2005	0.8 MCM Balloon (547N)	Ft. Sumner, NM	Success
9/9/2005	Orion (30.062 DR)	White Sands Missile Range, NM	Success
9/9/2005	Orion (30.063 DR)	White Sands Missile Range, NM	Success
9/13/2005	0.01 MCM Balloon (548N)	Ft. Sumner, NM	Success
9/20/2005	0.8 MCM Balloon (549N)	Ft. Sumner, NM	Success
9/29/2005	Orion (30.070 DR)	White Sands Missile Range, NM	Success
[1] Balloon/Mission failure - failed on ascent (reflown successfully)			
[2] Terrier Improved Orion clamp release failure			
[3] 3rd stage Black Brant MK1 failed to ignite			
[4] Balloon success/experiment failure			
[5] Experiment failure			

SUMMARY

Every year there are more exciting range safety accomplishments and more special interest items to report, and 2005 was no exception. The Range Safety Requirements document, NPR 8715.5, was officially released; the training program continued on schedule with completion of the Range Flight Safety Systems Course; and independent assessments were conducted on the range safety programs at Dryden, Wallops and Johnson. Exciting new technologies like STARS, EFTS, AFSS, JARSS and BMRST, continue to evolve, and the Constellation and ELV Payload Safety Programs were initiated. As other countries and other commercial ventures enter the launch arena, and as the moon and Mars become viable targets, the future promises to be even more exciting.

Anyone having questions or wishing to have an article included in the FY 2006 NASA Range Safety Annual Report should contact Maria Collura, the Agency Range Safety Program Manager located at the Kennedy Space Center, or Michael Dook at NASA Headquarters.

The 2005 Range Safety Annual Report was
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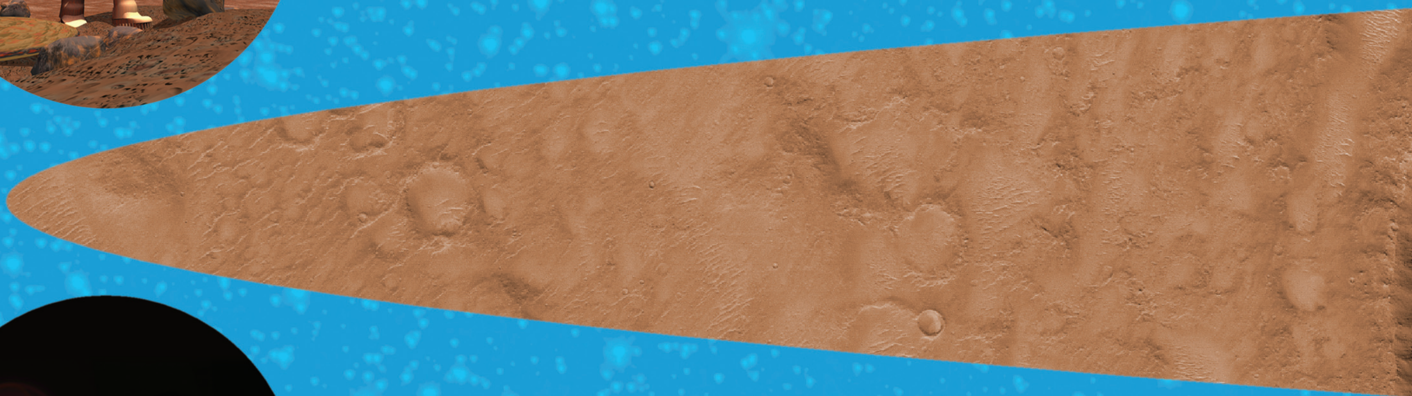

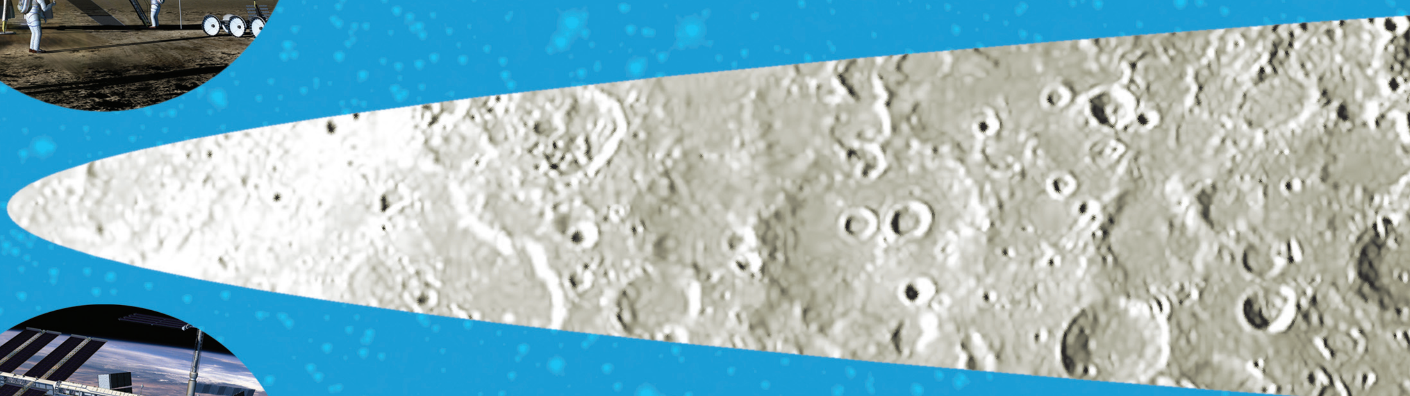

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